Safety Reference Manual

Allen-Bradley

Using ControlLogix in SIL 2 Applications

Catalog Numbers 1756-L6x, 1756-L7x

Allen-Bradley • Rockwell Software

Rockwell Automation

Important User Information

Read this document and the documents listed in the additional resources section about installation, configuration, and operation of this equipment before you install, configure, operate, or maintain this product. Users are required to familiarize themselves with installation and wiring instructions in addition to requirements of all applicable codes, laws, and standards.

Activities including installation, adjustments, putting into service, use, assembly, disassembly, and maintenance are required to be carried out by suitably trained personnel in accordance with applicable code of practice.

If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

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	WARNING: Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.
	ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you identify a hazard, avoid a hazard, and recognize the consequence.
IMPORTANT	Identifies information that is critical for successful application and understanding of the product.

Labels may also be on or inside the equipment to provide specific precautions.

	SHOCK HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that dangerous voltage may be present.
	BURN HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that surfaces may reach dangerous temperatures.
	ARC FLASH HAZARD: Labels may be on or inside the equipment, for example, a motor control center, to alert people to potential Arc Flash. Arc Flash will cause severe injury or death. Wear proper Personal Protective Equipment (PPE). Follow ALL Regulatory requirements for safe work practices and for Personal Protective Equipment (PPE).

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This manual contains new and updated information. Changes throughout this revision are marked by change bars as shown to the right of this paragraph.

New and Updated Information

This table lists the major changes made with this revision.

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This safety reference manual is intended to do the following:

- Describe the ControlLogix® Control System components available from Rockwell Automation that are suitable for use in low demand and high demand (no more than 10 demands per year) safety-related control, up to and including SIL 2 applications
- Provide safety-related information specific to the use of ControlLogix modules in SIL 2 systems - including PFD calculations that need to be considered for SIL 2-certified systems
- Explain some possible SIL 2-certified system configurations
- Describe basic programming techniques for the implementation of ControlLogix SIL 2-certified systems with references and links to more-detailed programming and implementation techniques

IMPORTANT This manual describes typical SIL 2 implementations using ControlLogix equipment. Keep in mind that the descriptions presented in this manual do not preclude other methods of implementing a SIL 2-compliant system by using ControlLogix equipment.

Other methods should be reviewed and approved by a recognized certifying body, such as TÜV Rheinland Group.

Terminology

This table defines abbreviations used in this manual.

Table 1 - Abbreviations Used throughout This Reference Manual

Abbreviation	Full Term	Definition
CIP	Common Industrial Protocol	A industrial communication protocol used by Logix5000™-based automation systems on EtherNet, ControlNet, and DeviceNet communication networks.
CL	Claim Limit	The maximum level that can be achieved.
DC	Diagnostic Coverage	The ratio of the detected failure rate to the total failure rate.
—	Demand	A safe-state safety action initiated by the safety function. A normal control action/function is not a safety demand. A safety demand occurs when safety conditions are met. Typically this only occurs when standard control fails to perform its control function
—	Demand Rate	The expected rate (per year) that a safe-state safety action will be executed by the safety function.
EN	European Norm.	The official European Standard.
GSV	Get System Value	A ladder logic instruction that retrieves specified controller information and places it in a destination tag.
MTBF	Mean Time Between Failures	Average time between failure occurrences.

Table 1 - Abbreviations Used throughout This Reference Manual

Abbreviation	Full Term	Definition
MTTR	Mean Time to Restoration	Average time needed to restore normal operation after a failure has occurred.
PADT	Programming and Debugging Tool	RSLogix™ 5000 software is used to program and debug a SIL 2-certified ControlLogix application.
PC	Personal Computer	Computer used to interface with, and control, a ControlLogix system via the RSLogix 5000 software.
PFD	Probability of Failure on Demand	The average probability of a system to fail to perform its design function on demand.
PFH	Probability of Failure per Hour	The probability of a system to have a dangerous failure occur per hour.
SFF	Safe Failure Fraction	The ratio of safe failure plus dangerous detected failure to total failures.
SIL	Safety Integrity Level	A discrete level for specifying the safety integrity requirements of the safety functions allocated to the electrical/electronic/ programmable electronic (E/E/PE) part of the safety system.
STR	Spurious Trip Rate	That part of the overall failure rate that does not lead to a dangerous undetected failure.
T_{CE}	Channel Equivalent Mean Downtime	The sum of downtime contributions from both the dangerous detected failure rate and the dangerous undetected failure rate, on a per channel basis
T_{GE}	System Equivalent Downtime	The sum of downtimes resulting from dangerous detected and dangerous undetected failure rates associated with both channels.

Additional Resources

These resources contain more information related to the ControlLogix system.

Resource	Description
ControlLogix SIL 2 System Configuration Using RSLogix 5000 Subroutines, publication 1756-AT010	Explains how to configure a SIL 2-certified system by using subroutines provided by Rockwell Automation.
ControlLogix SIL 2 System Configuration Using RSLogix 5000 Subroutines, publication 1756-AT012	Explains how to configure a SIL 2-certified system by using Add-On Instructions provided by Rockwell Automation.
Logix5000 Controllers General Instruction Set Reference Manual, publication 1756-RM003	Contains descriptions and use considerations of general instructions available for Logix5000 controllers.
ControlLogix System User Manual, publication 1756-UM001	Explains how to use the ControlLogix controllers.
ControlLogix Standard Redundancy System User Manual, publication 1756-UM523	Explains how to install, configure, and use a standard redundancy system.
ControlLogix Enhanced Redundancy System User Manual, publication 1756-UM535	Explains how to install, configure, and use an enhanced redundancy system.
ControlLogix Digital I/O User Manual, publication 1756-UM058	Provides information about the use of ControlLogix digital I/O modules.
ControlLogix Analog I/O Modules User Manual, publication 1756-UM009	Provides information about the use of ControlLogix analog I/O modules.
Logix5000 Controllers Execution Time and Memory Use Reference, publication 1756-RM087	Provides estimated execution times that can be used in worst-case scenario calculations.
Logix5000 Controllers Common Procedures Programming Manual, publication 1756-PM001	Explains a variety of programming-related topics.
Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1	Provides general guidelines for installing a Rockwell Automation industrial system.
Product Certifications website, http://www.ab.com	Provides declarations of conformity, certificates, and other certification details.

In addition to the manuals listed, you may want to reference installation instructions listed in Appendix B.

You can view or download publications at http://www.rockwellautomation.com/literature/. To order paper copies of technical documentation, contact your local Allen-Bradley® distributor or Rockwell Automation sales representative.

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SIL Policy

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Introduction to Safety Integrity Level (SIL)

Certain catalog numbers of the ControlLogix system (listed in Appendix B) are type-approved and certified for use in SIL 2 applications according to these standards:

- IEC 61508, edition 2, 2010 (this manual describes architectures required to achieve edition 2)
- IEC 61511

Approval requirements are based on the standards current at the time of certification.

These requirements consist of mean time between failures (MTBF), probability of failure, failure rates, diagnostic coverage and safe failure fractions that fulfill SIL 2 criteria. The results make the ControlLogix system suitable up to and including SIL 2 for demand rates up to and including ten demands per year.

The TÜV Rheinland Group has approved the ControlLogix system for use in up to, and including, SIL 2 safety-related applications in which the de-energized state is typically considered to be the safe state. All of the examples related to I/O included in this manual are based on achieving de-energization as the safe state for typical emergency shutdown (ESD) systems.

Life expectancy for the ControlLogix system components is 20 years.

IMPORTANT Keep in mind that a demand is an event where the safety function is executed. A ControlLogix system can be configured to execute standard control as well as safety functions. The demand rate is determined by how often the safety function is executed and not how often the control function is executed.

Programming and Debugging Tool (PADT)

For support in creation of programs, the PADT (Programming and Debugging Tool) is required. The PADT for ControlLogix is RSLogix™ 5000 software, per IEC 61131-3, and this Safety Reference Manual.

For more information about programming a system by using optional pre-developed Add-On Instructions, refer to ControlLogix SIL 2 System Configuration Using SIL 2 Add-On Instructions, publication 1756-AT012.

About the ControlLogix System

The ControlLogix system is a modular programmable automation system with the ability to pre-configure outputs and other responses to fault conditions. As such, a system can be designed to meet requirements for 'hold last state' in the event of a fault so that the system can be used in up to, and including, SIL 2-level Gas and Fire and other applications that require that output signals to actuators remain ON. By understanding the behavior of the ControlLogix system for an emergency shutdown application, you can incorporate appropriate system design measures to meet other application requirements. These measures relate to the control of outputs and actuators, which must remain ON to be in a safe state. Other requirements for SIL 2 (inputs from sensors, software used, and so on) must also be met.

IMPORTANT When used in accordance with the information in this manual and the relevant safety standards, the ControlLogix system is suitable for applications up to and including SIL 2, where the demand rate is no more than 10 times per year.

Gas and Fire Considerations

Listed below are the measures and modifications related to the use of the ControlLogix system in Gas and Fire applications.

- The use of a manual override is necessary to make sure the operator can maintain the desired control in the event of a controller failure. This is similar in concept to the function of the external relay or redundant outputs required to make sure a de-energized state is achieved for an ESD system should a failure occur (for example, a shorted output driver) that would prevent this from normally occurring. The system knows it has a failure, but the failure state requires an independent means to maintain control and either remove power or provide an alternate path to maintain power to the end actuator.

- If the application cannot tolerate an output that can fail shorted (energized), then an external means such as a relay or other output must be wired in series to remove power when the fail shorted condition occurs. See Wiring ControlLogix Digital Output Modules on page 54 for more information.

- If the application cannot tolerate an output that fails open (de-energized), then an external means such as a manual override or output must be wired in parallel. See Figure 1. The user must supply the alternative means and develop the application program to initiate the alternate means of removing or continuing to supply power in the event the main output fails.

- This manual override circuit is shown in Figure 1. It is composed of a hard-wired set of contacts from a selector switch or push-button. One normally-open contact provides for the bypass of power from the controller output directly to the actuator. The other is a normally-closed contact to remove or isolate the controller output.

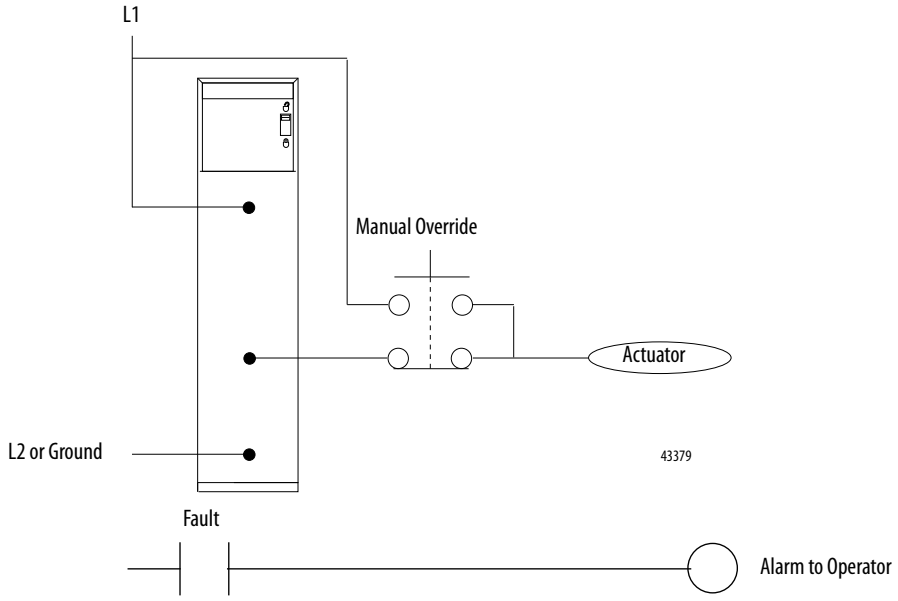
- An application program needs to be generated to monitor the diagnostic output modules for dangerous failures such as shorted or open-output driver channels. Diagnostic output modules must be configured to hold last state in the event of a fault.

- A diagnostic alarm must be generated to inform the operator that manual control is required.

- The faulted module must be replaced within the Mean Time to Restoration (MTTR).

- Any time a fault is detected, the system must annunciate the fault to an operator by some means (for example, an alarm light).

Figure 1 - Manual Override Circuit



Boiler and Combustion Considerations

If your SIL 2-certified ControlLogix system is used in combustion-related applications, you are responsible for meeting appropriate safety standards including National Fire Protection Association (NFPA) standard NFPA 85 and 86. In addition, you must provide a documented life-cycle system safety analysis that addresses all the requirements of NFPA 85 related to Burner Management System Logic.

To comply with the requirements of IEC 61508, the safety demand rate must be no more than 10 demands per year.

You should also consider system reaction capability as explained in Appendix A.

If your system must meet standard EN 50156, then you must also meet the requirements identified in the current version of EN 50156. To use FLEX™ I/O or 1756-series I/O modules in SIL 2 EN50156 applications, you must use a GuardLogix® controller. Refer to the GuardLogix Safety Reference Manual, publication 1756-RM093.

IMPORTANT	When using a GuardLogix controller with SIL 2-rated 1756 or 1794 I/O, you must also follow the requirements defined in this manual.

Typical SIL 2 Configurations

SIL 2-certified ControlLogix systems can be used in standard (simplex) or high-availability (duplex) configurations. For the purposes of documentation, the various levels of availability that can be achieved by using various ControlLogix system configurations are referred to as simplex or duplex.

This table lists each system configuration and the hardware that is part of the system's safety loop.

System Configuration	Safety Loop Includes
Simplex Configuration on page 17	• Single controller • Single communication module • Dual I/O modules
Duplex Logic Solver Configurations on page 24	• Dual controllers • Dual communication modules • Dual I/O modules
Duplex System Configuration on page 25	• Dual controllers • Dual communication modules • Dual I/O modules • I/O termination boards

IMPORTANT The system user is responsible for the following tasks when any of the ControlLogix SIL 2 system configurations are used:

- The setup, SIL rating, and validation of any sensors or actuators connected to the ControlLogix control system
- Project management and functional testing
- Programming the application software and the module configuration according to the descriptions in this manual

The SIL 2 portion of the certified system excludes the development tools and display/human machine interface (HMI) devices; these tools and devices must not be part of the safety loop.

Simplex Configuration

In a simplex configuration, the hardware used in the safety loop is programmed to fail to safe. The failure to safe is typically an emergency shutdown (ESD) where outputs are de-energized.

Figures 2 ...9 each show typical simplex SIL loops. The figures show the following:

- Overall safety loop
- ControlLogix portion of the overall safety loop

SIL 2 I/O modules in the safety loop must meet the requirements specified in Chapter 5, ControlLogix I/O Modules and Chapter 6, FLEX I/O Modules.

Figure 2 - Single-chassis Configuration

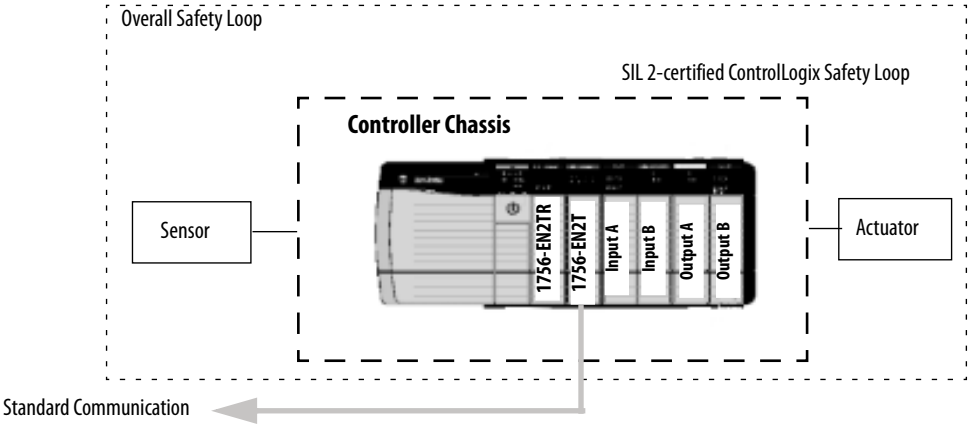


Figure 3 - Fail-safe ControlLogix EtherNet/IP DLR Configuration

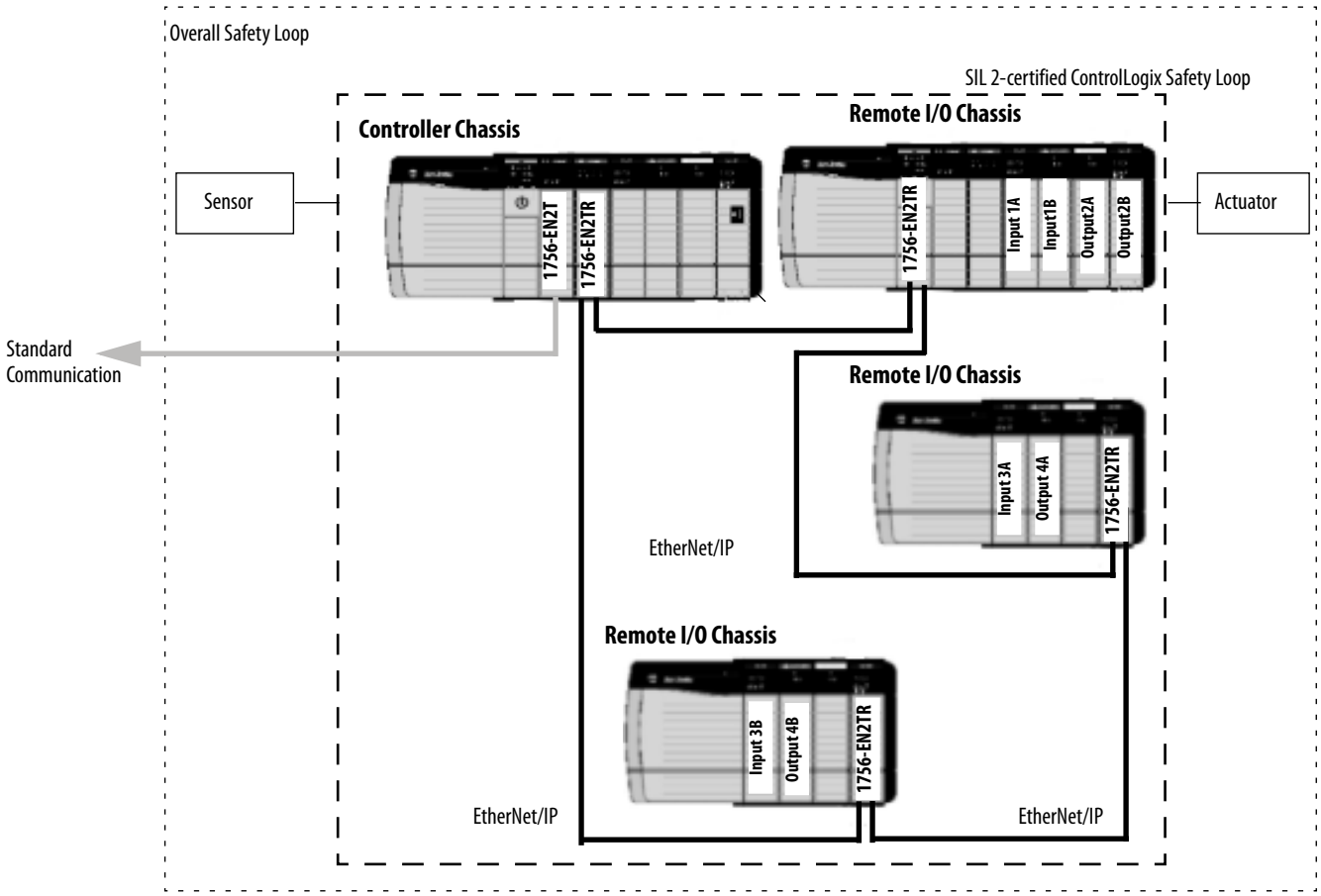
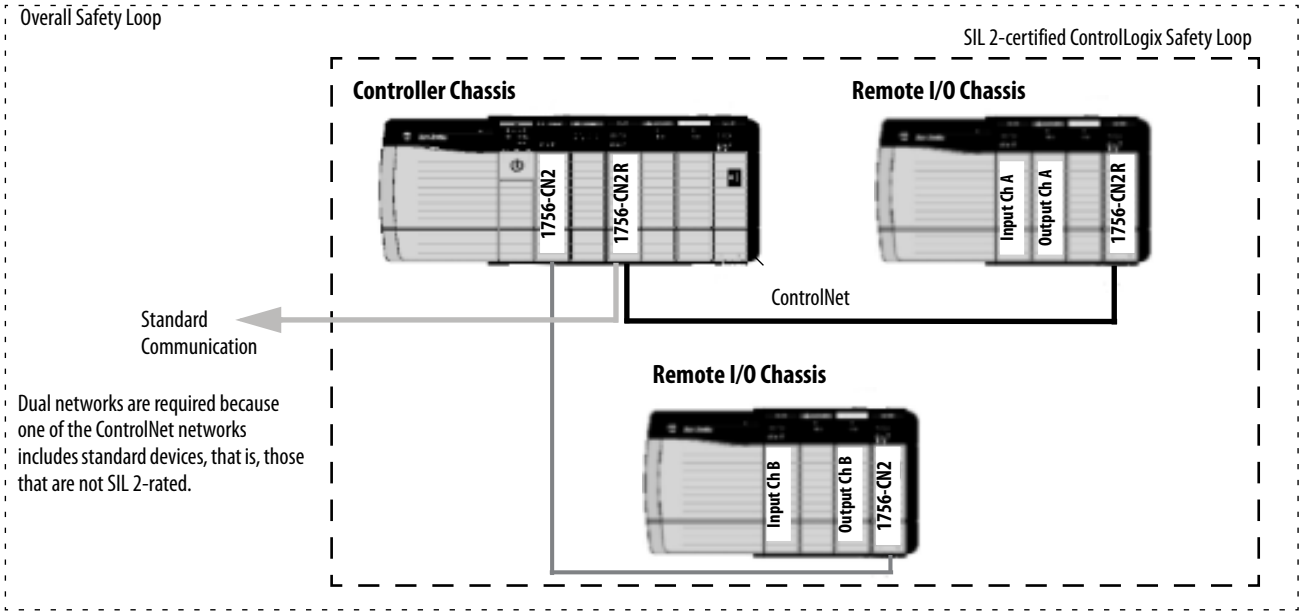


Figure 4 - Fail-safe ControlLogix ControlNet Configuration (Safety and Standard Connections on the Same Network)



In Figure 5, non-SIL 2 communication on separate subnets lets you place redundant channel I/O in the same rack.

Figure 5 - Fail-safe ControlLogix ControlNet Configuration with Non-SIL 2 Communication (Safety and Standard Connections on Separate Networks)

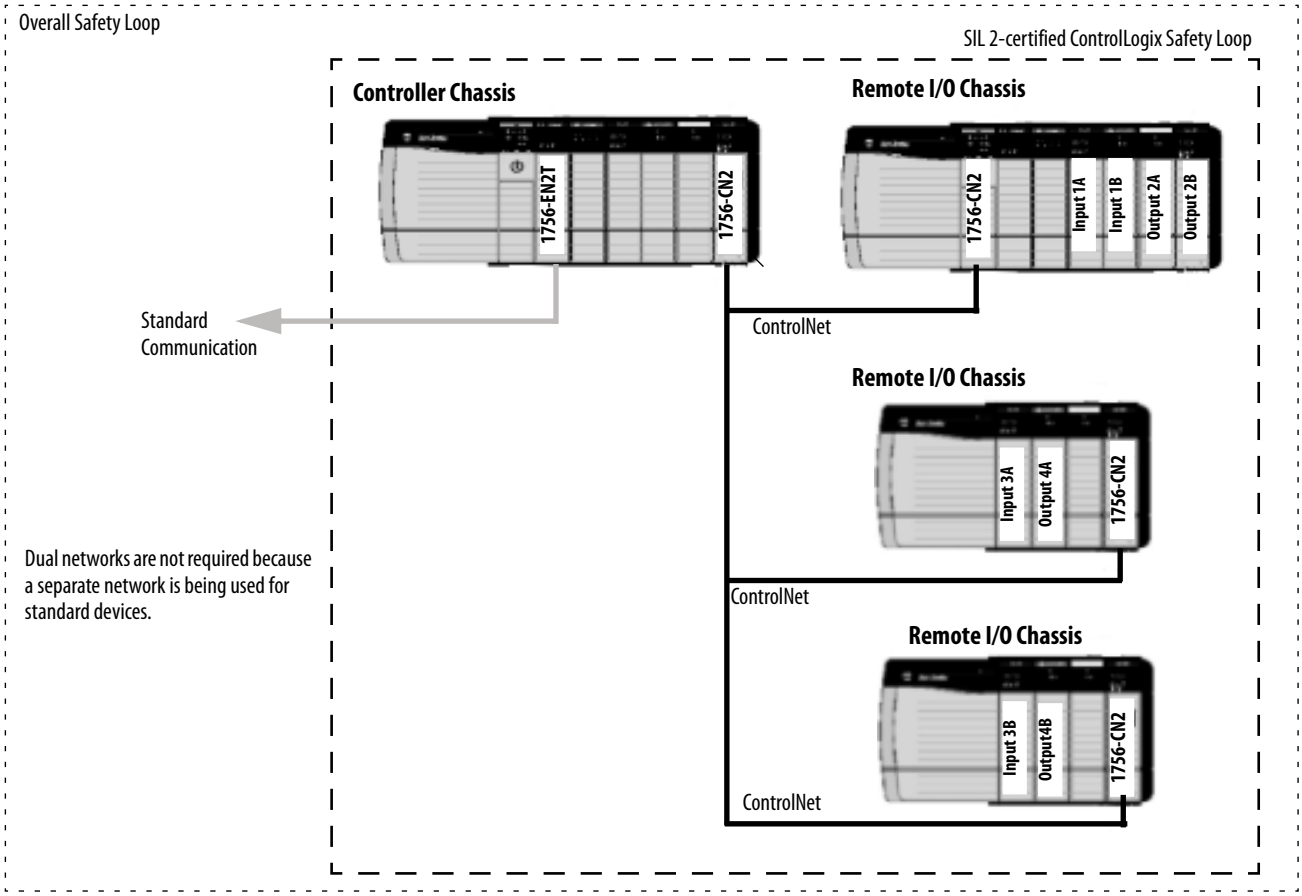


Figure 6 - Fail-safe ControlLogix EtherNet/IP Configuration: Single DLR Loop for Safety and Standard Communication

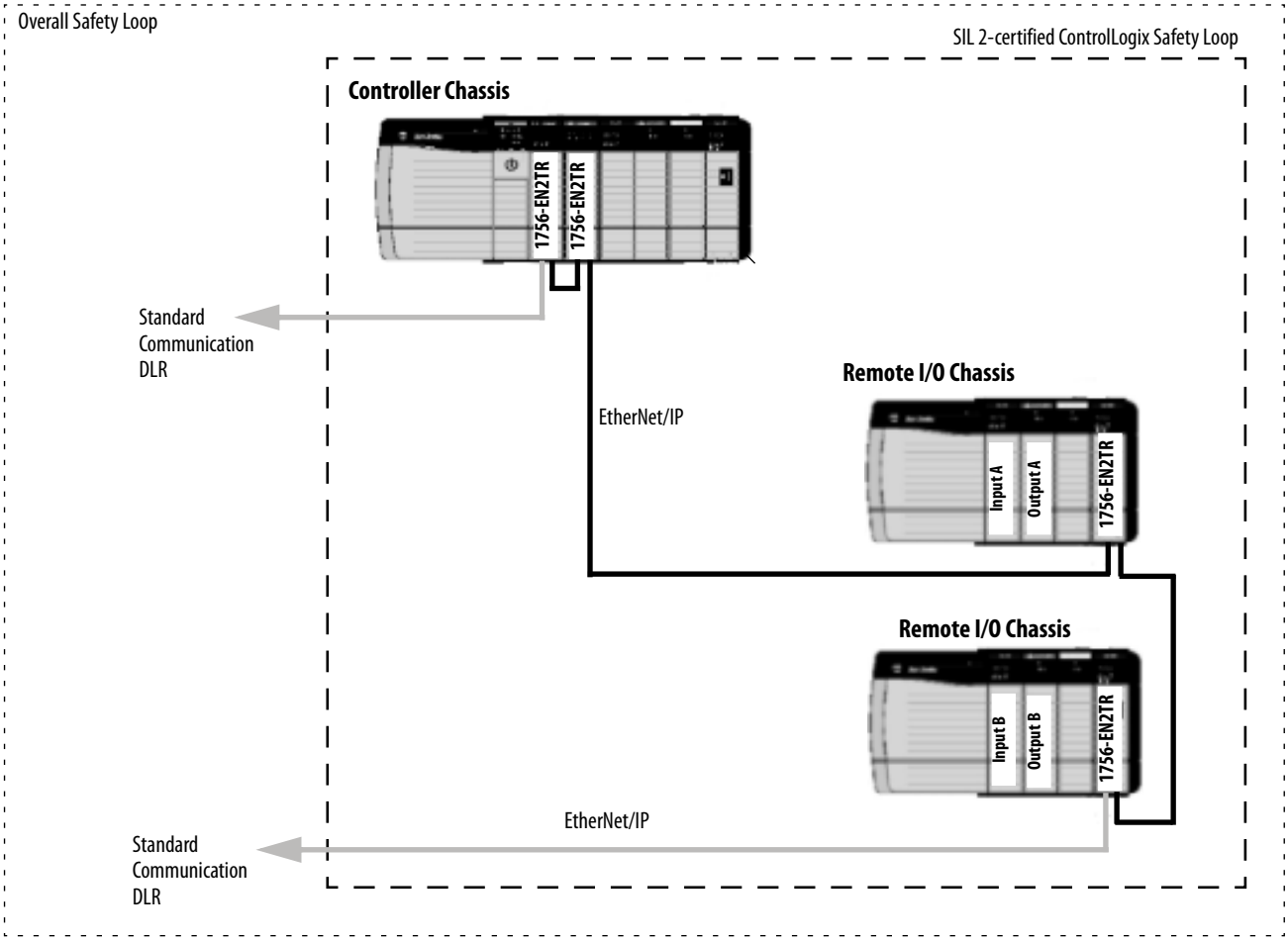
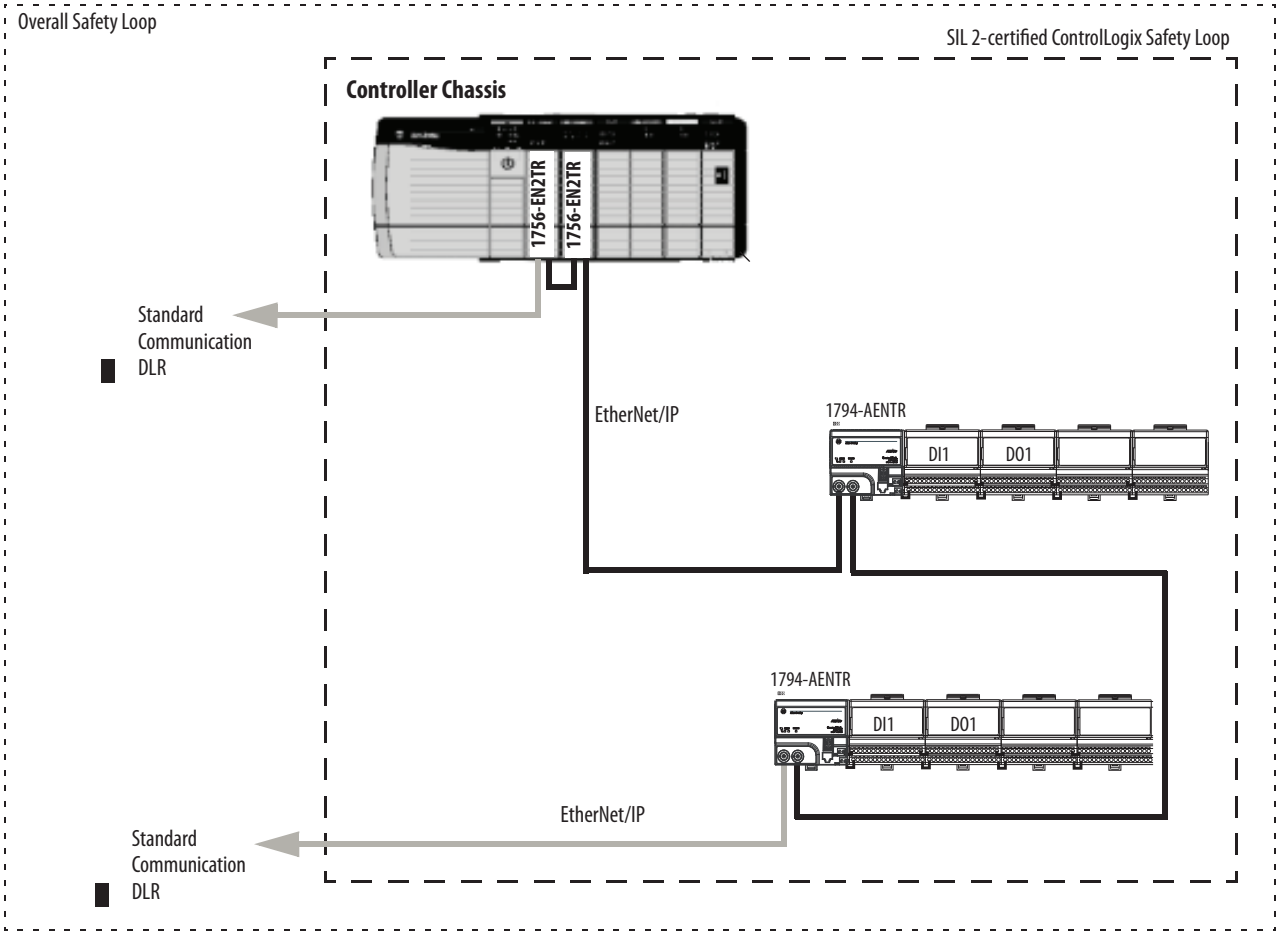


Figure 7 - Fail-safe ControlLogix EtherNet/IP Configuration with FLEX I/O Modules: Single DLR Loop for Safety and Standard Communication

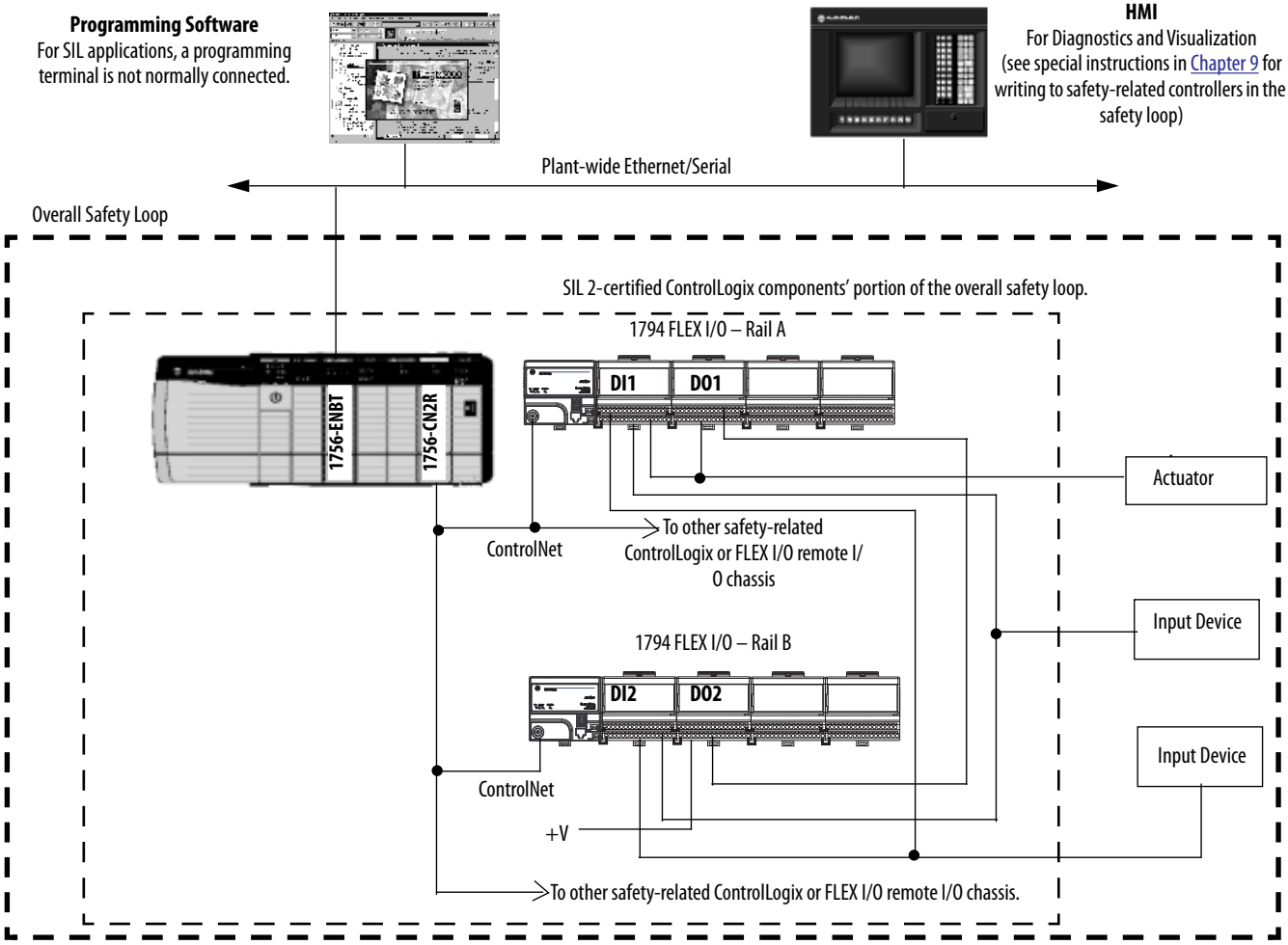


IMPORTANT As shown in Figure 6 and Figure 7, standard devices can reside within an EtherNet/IP™ SIL 2 subnet provided the following requirements are met:

- The EtherNet/IP subnet topology must be DLR.
- The ControlLogix chassis must have two 1756-EN2TR modules.
  - Independent connection paths must be established for channels A and B I/O through each ControlLogix chassis bridge module.
- Channel A and Channel B I/O must reside in separate chassis or connected to separate adapters.
- Direct Internet connectivity must be limited to EtherNet/IP bridge modules listed in Appendix B of this manual.

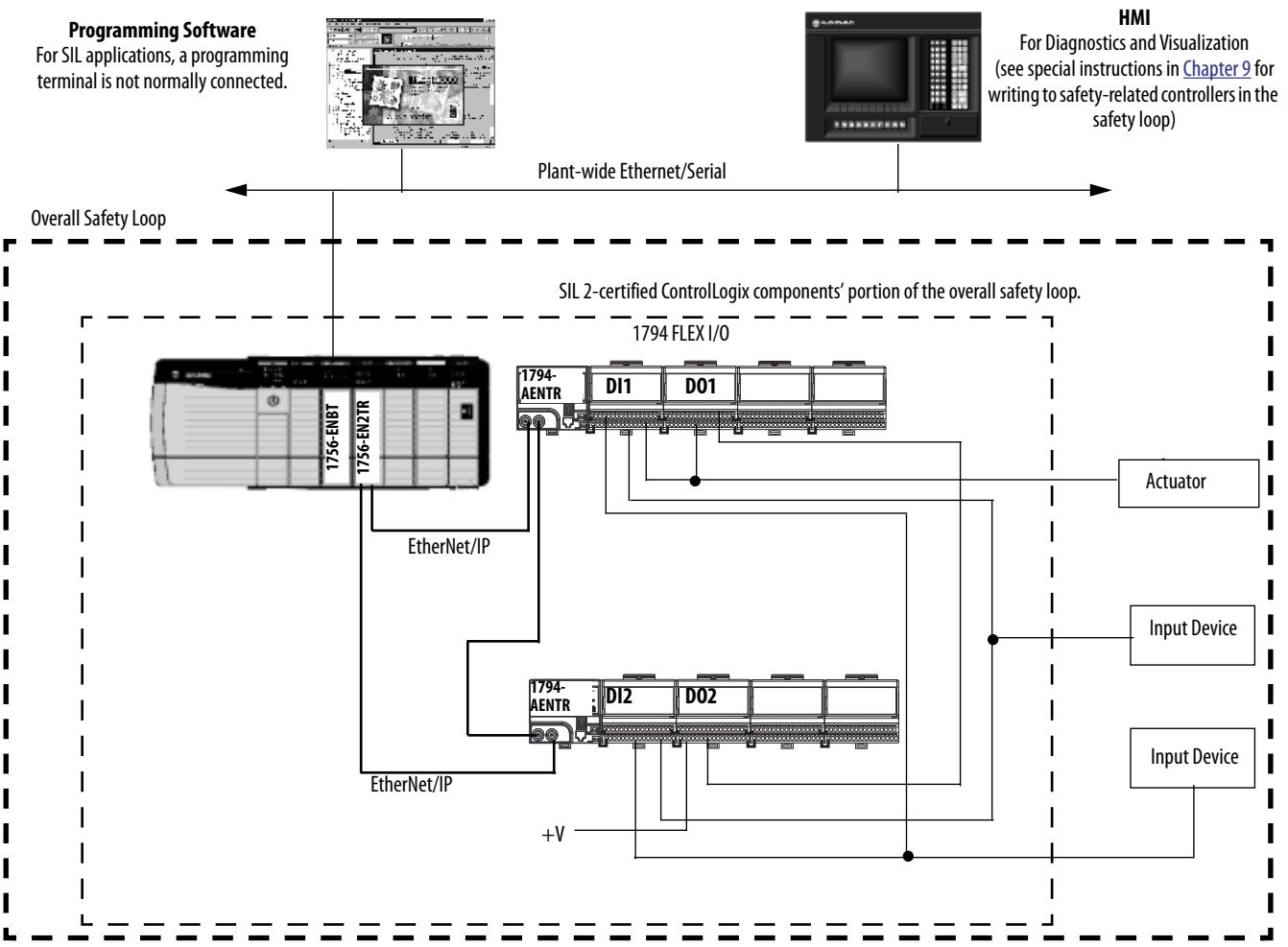
Direct Internet connections via other standard devices are not allowed.

Figure 8 - Fail-safe ControlLogix Configuration with FLEX I/O Modules on ControlNet Network


Programming Software
For SIL applications, a programming terminal is not normally connected.
HMI
For Diagnostics and Visualization (see special instructions in Chapter 9 for writing to safety-related controllers in the safety loop)
Plant-wide Ethernet/Serial
Overall Safety Loop
SIL 2-certified ControlLogix components' portion of the overall safety loop.
1794 FLEX I/O – Rail A
1756-ENBT
1756-CN2R
DI1
DO1
Actuator
ControlNet
To other safety-related ControlLogix or FLEX I/O remote I/O chassis
Input Device
1794 FLEX I/O – Rail B
DI2
DO2
Input Device
ControlNet
+V
To other safety-related ControlLogix or FLEX I/O remote I/O chassis.

Note 1: Multiple 1756-CNB or -CNBR modules can be installed into the chassis as needed. Other configurations are possible as long as they are SIL 2 approved.
Note 2: Two adapters are required for meeting SIL 2 as shown in the figure. The adapters can be either ControlNet or Ethernet and must be from the list of approved products.

Figure 9 - Fail-safe ControlLogix Configuration with FLEX I/O Modules on EtherNet/IP Network

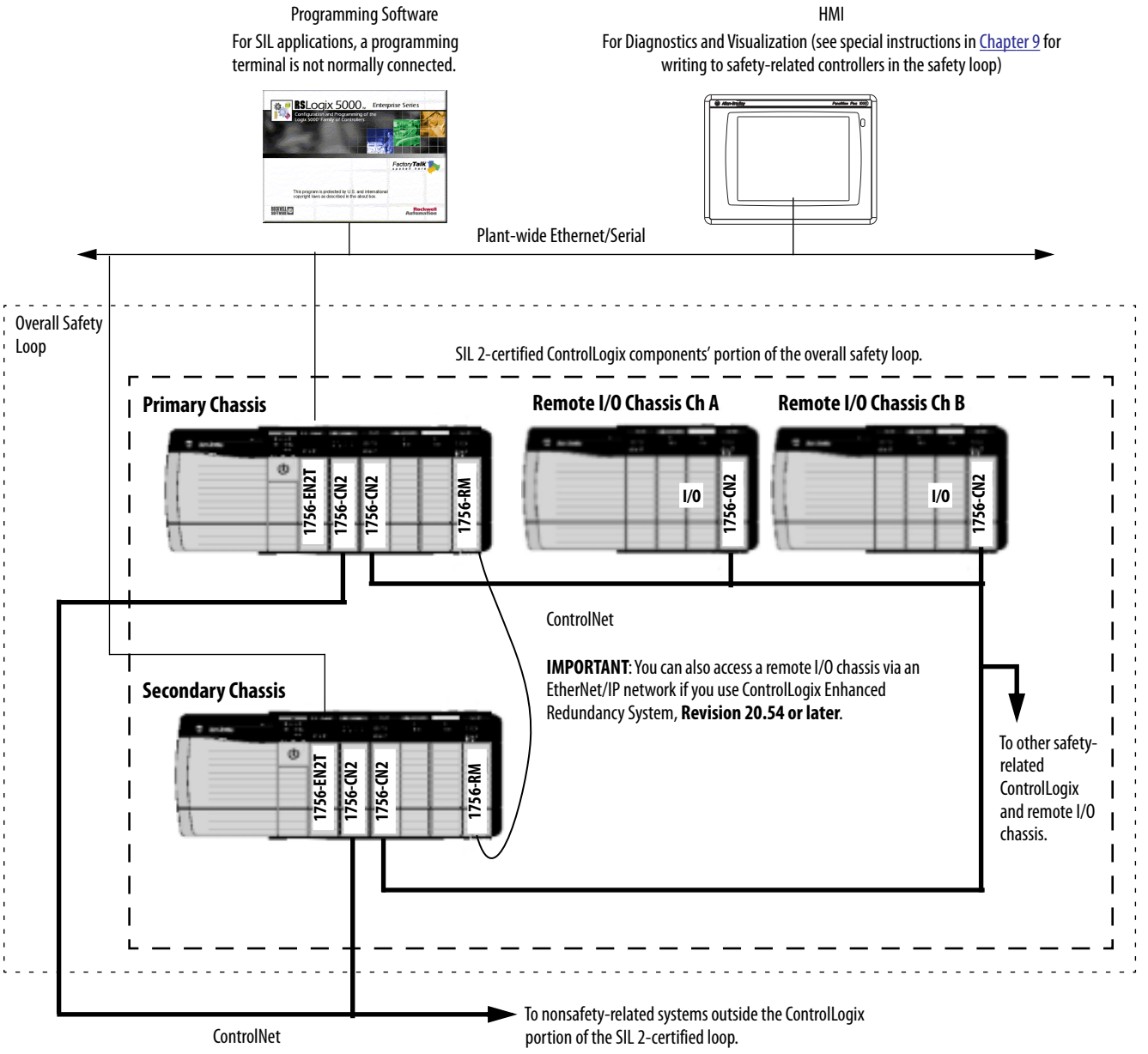


Duplex Logic Solver Configurations

In duplex configurations, redundant system components are used to increase the availability of the control system. The modules in the redundant controller chassis include redundancy modules and network communication modules for redundant communication, as well as the ControlLogix controllers.

SIL 2 I/O modules in the safety loop must meet the requirements specified in Chapter 5, ControlLogix I/O Modules.

Figure 10 - Typical SIL Loop with Controller Chassis Redundancy


Programming Software
For SIL applications, a programming terminal is not normally connected.
HMI
For Diagnostics and Visualization (see special instructions in Chapter 9 for writing to safety-related controllers in the safety loop)
Plant-wide Ethernet/Serial
Overall Safety Loop
SIL 2-certified ControlLogix components' portion of the overall safety loop.
Primary Chassis
Remote I/O Chassis Ch A
Remote I/O Chassis Ch B
1756-EN2T
1756-CN2
1756-CN2
1756-RM
I/O
1756-CN2
I/O
1756-CN2
ControlNet
IMPORTANT: You can also access a remote I/O chassis via an EtherNet/IP network if you use ControlLogix Enhanced Redundancy System, Revision 20.54 or later.
Secondary Chassis
1756-EN2T
1756-CN2
1756-CN2
1756-RM
To other safety-related ControlLogix and remote I/O chassis.
ControlNet
To nonsafety-related systems outside the ControlLogix portion of the SIL 2-certified loop.

IMPORTANT The redundant (duplex) ControlLogix system in Figure 10 provides logic solver fault tolerance.

Figure 10 shows a typical duplex SIL loop. The figure also shows the following:

- Overall safety loop
- ControlLogix portion of the overall safety loop
- How other devices (for example, HMI) connect to the loop, while operating outside the loop

Duplex System Configuration

This configuration of the ControlLogix system uses fully-redundant controllers, communication modules, and remote I/O devices to achieve enhanced availability.

Figure 11 - Duplex System EtherNet/IP Configuration

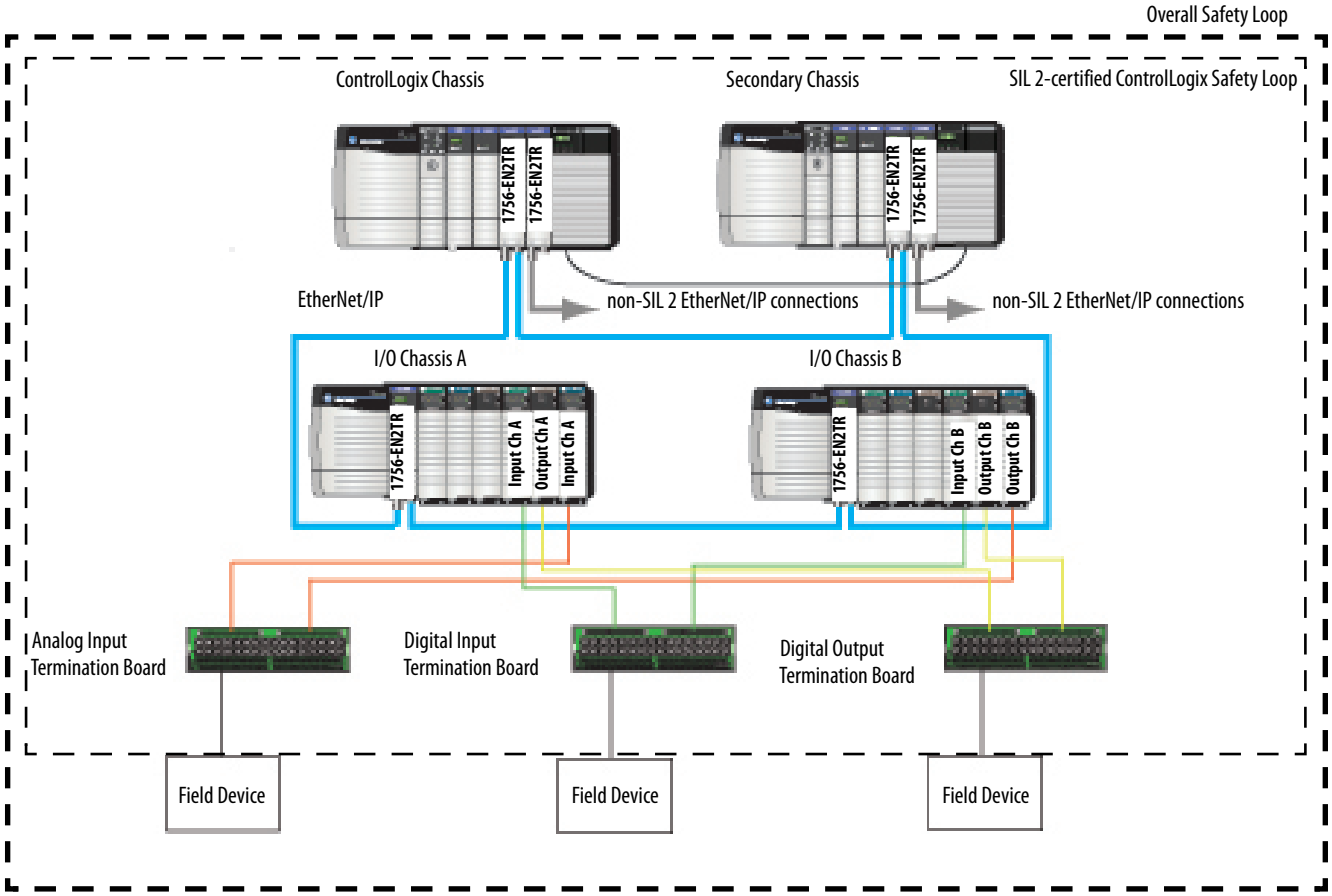
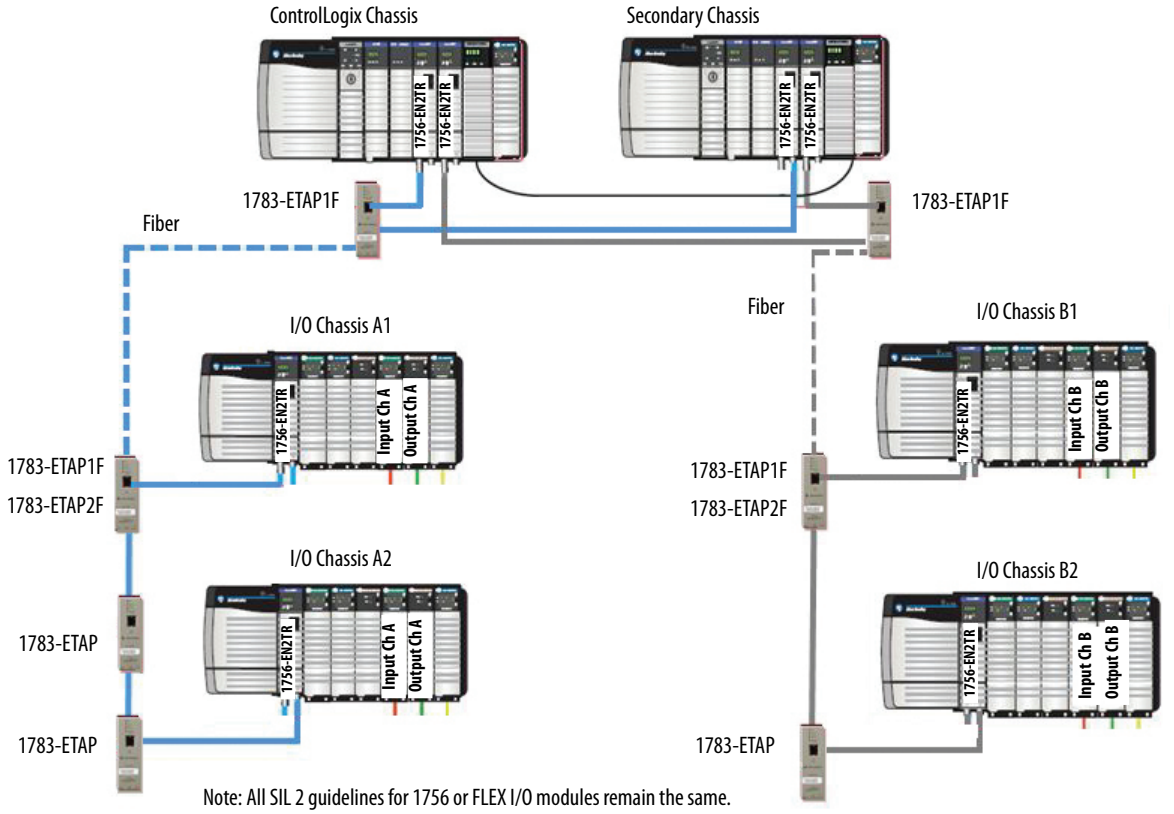


Figure 12 - Duplex System EtherNet/IP Fiber Configuration



Note: All SIL 2 guidelines for 1756 or FLEX I/O modules remain the same.

Because channel A and channel B are two independent networks, 1783-ETAP modules can be considered black channel equipment and do not need to be part of the SIL 2 system calculation.

Figure 13 - Duplex System with Stratix Switches

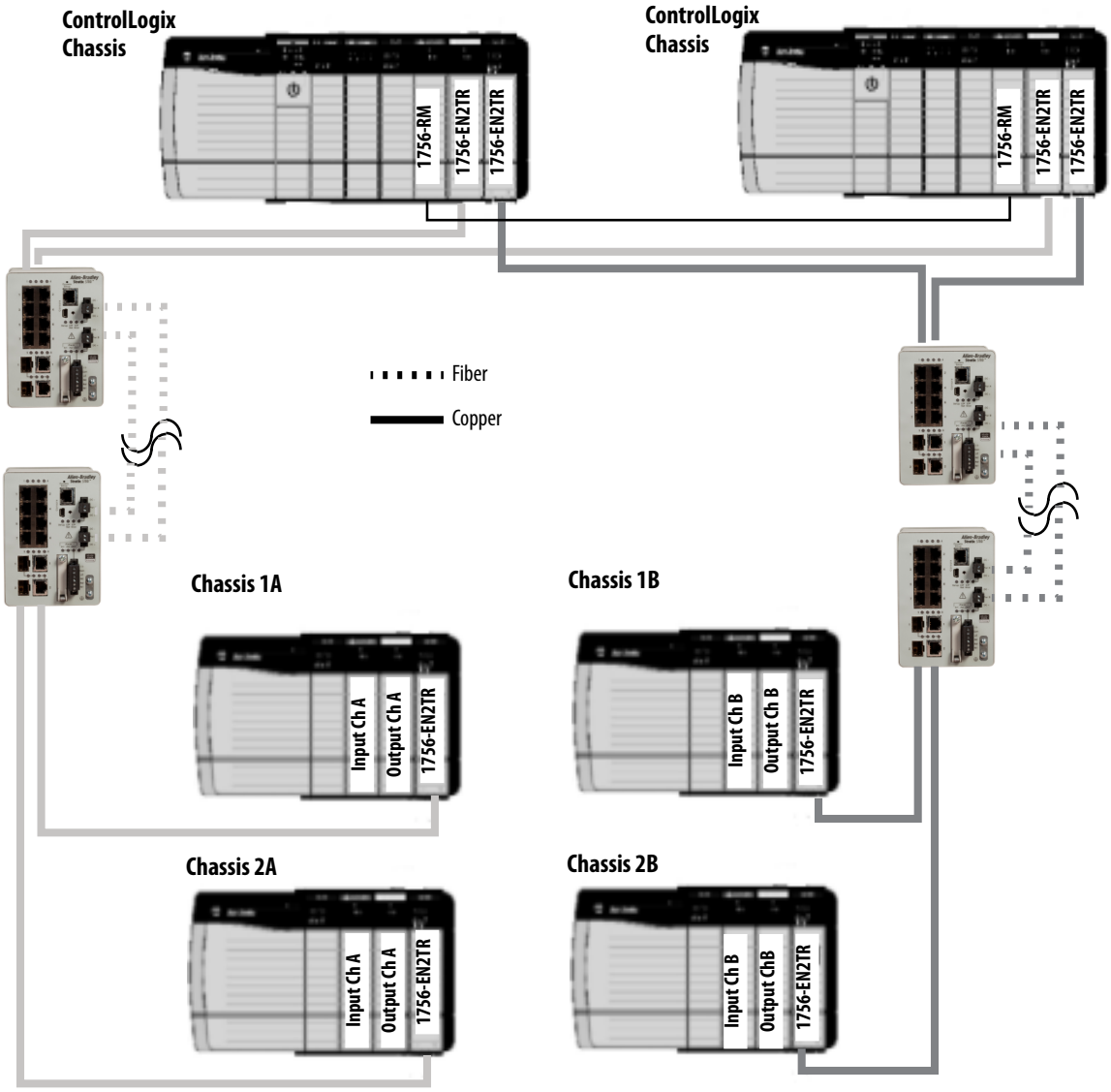
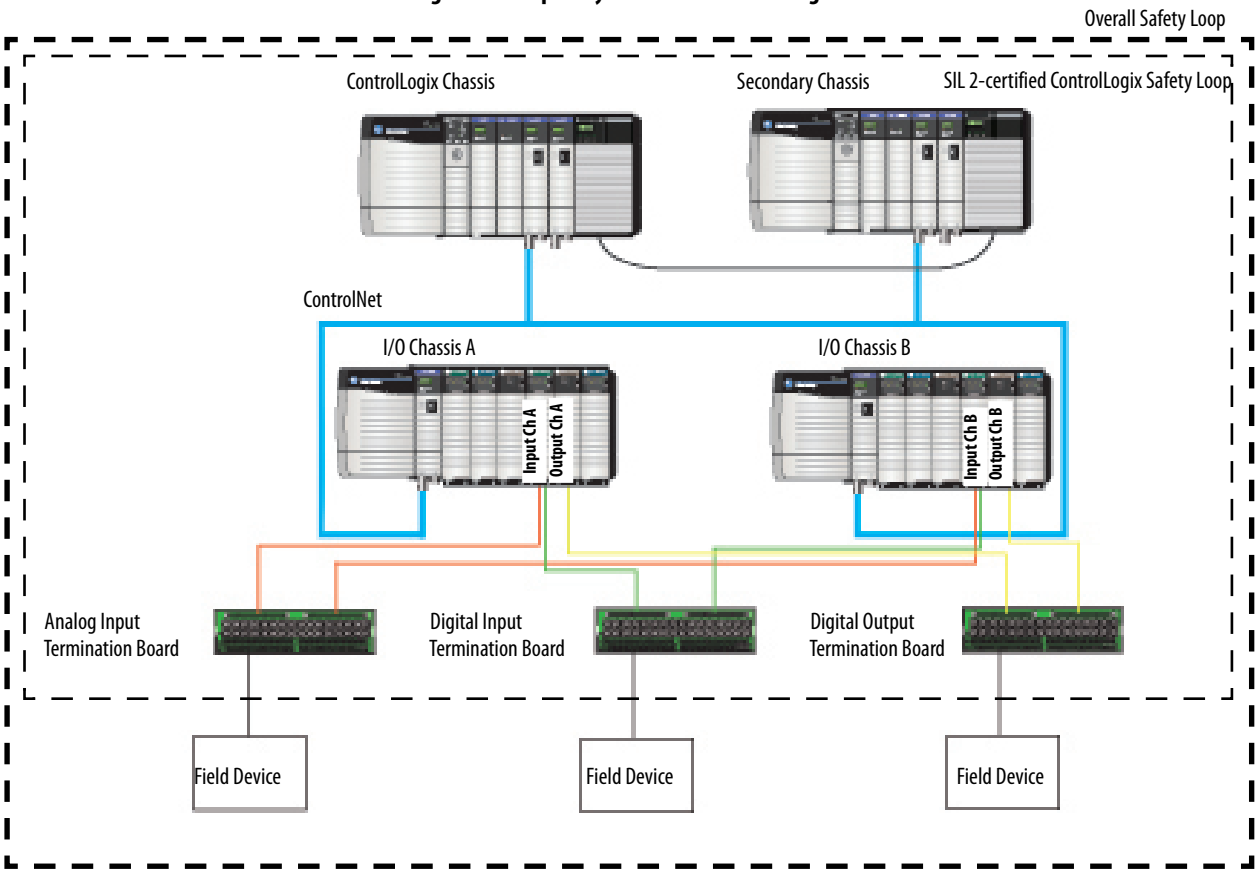


Figure 14 - Duplex System ControlNet Configuration



The duplex system configuration uses safety and programming principles described in this manual, as well as programming and hardware described in the application technique manuals.

For more information about the ControlLogix SIL 2-certified system, refer to ControlLogix SIL 2 System Configuration Using SIL 2 Add-On Instructions, publication 1756-AT012.

Proof Tests

IEC 61508 requires the user to perform various proof tests of the equipment used in the system. Proof tests are performed at user-defined times (for example, proof test intervals can be once a year, once every two years or whatever time frame is appropriate based on the SIL verification calculation) and could include some of the following tests:

- Test all safety application fault routines to verify that process parameters are monitored properly and the system reacts properly when a fault condition arises.

- Test all digital input or output channels to verify that they are not stuck in the ON or OFF state.
  - Manually cycle inputs to make sure that all inputs are operational and not stuck in the ON state.
  - Manually test outputs that do not support runtime pulse testing. **The relays in the redundant power supplies must be tested to make sure they are not stuck in the closed state.**

    Users can automatically perform proof tests by switching ground open on input modules and checking to make sure all input points go to zero (turn OFF.).
- Calibrate analog input and output modules to verify that accurate data is obtained from and used on the modules.

IMPORTANT Each specific application has its own time frame for the proof test interval.

Proof Testing with Redundancy Systems

A ControlLogix redundancy system uses an identical pair of ControlLogix chassis to keep your process running if a problem occurs with one of those chassis. When a failure occurs in the primary chassis, control switches to the secondary controller.

The switchover can be monitored so that the system notifies the user when it has occurred. In this case (that is, when a switchover takes place), we recommend that you replace the failed controller within the mean time to restoration (MTTR) for your application.

If you are using controller redundancy in a SIL 2 application, you must perform the proof test on the primary controller and on the secondary controller.

TIP If you are concerned about the availability of the secondary controller if the primary controller fails, it is good engineering practice to implement a switchover periodically (for example, once per proof test interval).

For more information on switchovers in ControlLogix redundancy systems and ControlLogix redundancy systems in general, see these redundancy system manuals:

- ControlLogix Standard Redundancy System User Manual, publication 1756-UM523
- ControlLogix Enhanced Redundancy System User Manual, publication 1756-UM535

Reaction Times

The response time of the system is defined as the amount of time it takes for a change in an input condition to be recognized and processed by the controller's logic program, and then to initiate the appropriate output signal to an actuator.

The system response time is the sum of the following:

- Input hardware delays
- Input filtering
- I/O and communication module RPI settings
- Controller program scan times
- Output module propagation delays
- Redundancy system switchover times (applicable in duplex systems)

Each of the times listed is variably dependent on factors such as the type of I/O module and instructions used in the logic program. For examples of how to perform these calculations, see Appendix A, Reaction Times of the ControlLogix System.

For more information on the available instructions and for a full description of logic operation and execution, see the following publications:

- Logix5000™ Controllers General Instruction Set Reference Manual, publication 1756-RM003
- ControlLogix System User Manual, publication 1756-UM001

Reaction Times in Redundancy Systems

The worst-case reaction time of a duplex system is different than a simplex system. The redundancy system has a longer reaction time because of the following:

- There are a series of cross-loading operations that continuously occur between the primary and secondary controllers. Cross-loading fresh data at the end of each program scan increases scan time.

  To minimize scan time by reducing cross-loading overhead, you can plan your project more efficiently (for example, minimize the use of SINT, INT, and single tags, and use arrays and user-defined data structures). Generally, the primary controller in a duplex system has a 20% slower response time than the controller in a simplex system.

- The switchover between controllers slows system response. The switchover time of a redundancy system depends on the network update time (NUT) of the ControlNet™ network.

  For more information about switchover times in redundancy systems, see one of these ControlLogix redundancy system user manuals:

  – ControlLogix Standard Redundancy System User Manual, publication 1756-UM523

  – ControlLogix Enhanced Redundancy System User Manual, publication 1756-UM535

IMPORTANT To avoid nuisance trips, you must account for the additional cross checking time of a duplex system when setting the watchdog time.

Safety Watchdog

Configure the properties of the task used for safety correctly for your application.

- Priority: must be the highest-priority task in the application (lowest number)
- Watchdog: the value entered for the SIL 2 safety task must be large enough for all logic in the task to be scanned

If the task execution time exceeds the watchdog time, a major fault occurs on the controller. Users must monitor the watchdog and program the system outputs to transition to the safe state (typically the OFF state) in the event of a major fault occurring on the controller. For more information on faults, see Chapter 8, Faults in the ControlLogix System.

See the ControlLogix System User Manual, publication 1756-UM001, for more information about setting the watchdog.

Safety Certifications and Compliances

Diagnostic hardware and firmware functions, as well as how you apply ControlLogix components, enable the system to achieve CL SIL 2 compliance.

IMPORTANT You must implement these requirements or at minimum the intent of the requirements defined in this manual to achieve CL SIL 2.

ControlLogix products referenced in this manual may have safety certifications in addition to the SIL certification. If a product has achieved agency certification, it is marked on the product label. To view additional safety certifications for products, go to http://www.ab.com and click the Product Certifications link.

Notes:

Features of the ControlLogix SIL 2 System

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Module Fault Reporting	33
Data Echo Communication Check	34
Pulse Test	35
Software	35
Communication	36
Electronic Keying of Modules in SIL 2 Applications	37

The diagnostic methods and techniques used in the ControlLogix platform let you configure and program ControlLogix controllers to perform checks on the total system, including configuration, wiring, and performance, as well as monitoring input sensors and output devices. Timestamping of I/O and diagnostic data also aid in diagnostics.

If an anomaly (other than automatic shutdown) is detected, the system can be programmed to initiate user-defined fault handling routines. Output modules can turn OFF selected outputs in the event of a failure. Diagnostic I/O modules self-test to make sure that field wiring is functioning. Output modules use pulse testing to make sure output switching devices are not shorted.

Module Fault Reporting

Every module in the system is 'owned' by one controller. Multiple controllers can share data, in addition to consuming data from non-owned modules. When a controller 'owns' an I/O module, that controller stores the module's configuration data, defined by the user; this data dictates how the module behaves in the system. Inherent in this configuration and ownership is the establishment of a 'heartbeat' between the controller and module, known as the requested packet interval (RPI).

The RPI defines a time interval in which the controller and I/O module must communicate with each other. If, for any reason, communication cannot be established or maintained (that is, the I/O module has failed, the communication path is unavailable, and so forth), the system can be programmed to run specialized routines, which can determine whether the system should continue functioning or whether the fault condition warrants a shutdown of the application. For example, the system can be programmed to retrieve the fault code of the failed module and make a determination, based on the type of fault, as to whether to continue operating.

This ability of the controller to monitor the health of I/O modules in the system and take appropriate action based on the severity of a fault condition gives the user complete control of the application's behavior. It is your responsibility to establish the course of action appropriate to your safety application.

For more information on Fault Handling, see Chapter 8, Faults in the ControlLogix System on page 99.

Data Echo Communication Check

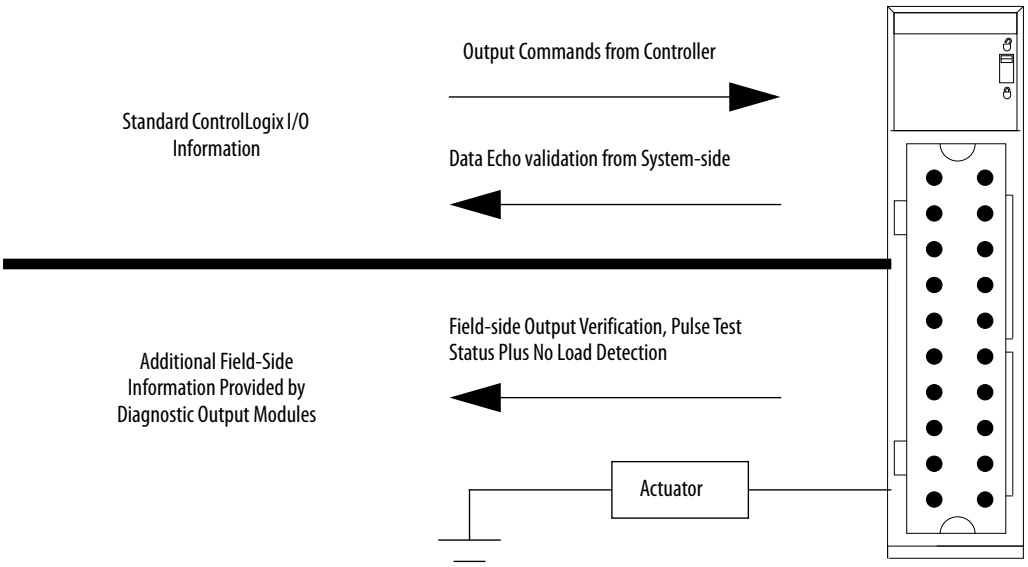
Output data echo allows the user to verify that an ON/OFF command from the controller was received by the correct output module, and that the module will attempt to execute the command to the field device.

During normal operation, when a controller sends an output command, the output module receiving that command will 'echo' the output command back to the controller upon its receipt. This verifies that the module has received the command and will try to execute it. By comparing the requested state from the controller to the data echo received from the module, you can validate that the signal has reached the correct module and that the module will attempt to activate the appropriate field-side device. The echo data is technically input data from the output module and is located with the other output module data. For example, an output module at local slot 3 will have Local:3:O and Local:3:I, where 3:O are outputs and 3:I are inputs. Again, it is your responsibility to establish the course of action appropriate for your safety application.

When used with standard ControlLogix output modules, the data echo validates the integrity of communication up to the system-side of the module, but not to the field-side. When you use this feature with diagnostic output modules, you can verify the integrity from the controller to the output terminal on the module.

Diagnostic output modules contain circuitry that performs field-side output verification. Field-side output verification informs you that commands received by the module are accurately represented on the power side of the module's switching devices. In other words, for each output point, this feature confirms that the output is ON when it is commanded to be ON or OFF when commanded to be OFF.

Figure 15 - Output Module Behavior in the ControlLogix System


Output Commands from Controller
Standard ControlLogix I/O Information
Data Echo validation from System-side
Field-side Output Verification, Pulse Test Status Plus No Load Detection
Additional Field-Side Information Provided by Diagnostic Output Modules
Actuator

Pulse Test

Discrete diagnostic output modules feature called a pulse test can verify output circuit functionality without actually changing the state of the actuator connected to the output. An extremely short-duration pulse is directed to a particular output on the module. The output circuitry will momentarily change its state long enough to verify that it can change state on demand. The test pulse is extremely fast (milliseconds), and typically does not affect actuators. Some actuators may have electronic front ends and be capable of detecting these fast pulses. You can disable pulse testing, if necessary.

Software

The location, ownership and configuration of I/O modules and controllers is performed using RSLogix 5000 software. The software is used for all creation, testing and debugging of application logic.

When using the programming software, you must remember these points:

- During normal control program (controller in Run mode):
  - disconnect the programming terminal.
  - set the key switch to the RUN position.
  - remove the controller key from the key switch.
- Authorized personnel may change an application program, but only by using one of the processes described in Changing Your Application Program on page 97.

Communication

Several communication options are available for connecting with the ControlLogix SIL 2 system and for the exchange of data within the SIL 2 system.

Communication Ports

A built-in serial port is available on 1756-L6*x* controllers for download or visualization purposes only. Do not use the serial port for any exchange of safety-related data.

A built-in USB port is available for program upload and download on 1756-L7*x* controllers.

ATTENTION: The USB port is intended for temporary local programming purposes only and not intended for permanent connection.

WARNING: Do not use the USB port in hazardous locations.

Refer to the ControlLogix System User Manual, publication 1756-UM001, for information on making communication connections.

ControlNet Network

The ControlNet network can be used to:

- provide communication between the controller and remote I/O chassis.
- form the basis for communication in duplex (redundant) configurations.

To schedule the ControlLogix ControlNet network, use RSNetWorx™ for ControlNet software.

For more information on ControlNet networks, refer to ControlNet Network Configuration Guide, publication CNET-UM001.

EtherNet/IP Network

An EtherNet/IP connection can be used to:

- download, monitor, and visualize the controller.
- connect to remote I/O chassis.

EtherNet/IP networks support messaging, produced/consumed tags, and distributed I/O.

See EtherNet/IP Communication Modules on page 45 for details on using EtherNet/IP modules in SIL 2 applications.

Electronic Keying of Modules in SIL 2 Applications

If a module in your SIL 2-certified ControlLogix system is replaced, Exact Match keying is recommended.

Exact Match keying requires all keying attributes, that is, Vendor, Product Type, Product Code (catalog number), Major Revision, and Minor Revision, of the physical module and the module created in the software to match precisely before establishing communication. If any attribute does not match precisely, I/O communication is not permitted with the module or with modules connected through it, as in the case of a communication module.

For more information about electronic keying, see the ControlLogix Digital I/O Modules User Manual, publication 1756-UM058.

Notes:

ControlLogix Controllers, Chassis, and Power Supplies

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Recommendations for Using Power Supplies	42

ControlLogix Controllers

The SIL 2-certified ControlLogix system is a user-programmed, solid-state control system. These are examples of specific functions:

- I/O control
- Logic
- Timing
- Counting
- Report generation
- Communication
- Arithmetic
- Data file manipulation

The ControlLogix controller consists of a central processor, I/O interface, and memory.

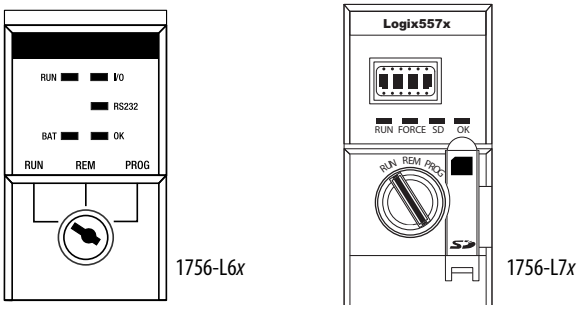
Operating Modes

The controller performs power-up and run-time functional tests. The tests are used with user-supplied application programs to verify proper controller operation.

A three-position keyswitch on the front of the controller governs ControlLogix system operational modes. The following modes are available:

- Run
- Program
- Remote - This software-enabled mode can be Program or Run.

Figure 16 - Keyswitch in Run Mode



When a SIL 2-certified ControlLogix application is operating in the Run mode, the controller keyswitch must be in the RUN position and the key removed.

Requirements for Use

Consider these requirements when using a SIL 2-certified ControlLogix controller:

- All components, such as input and output modules, for each safety function must be owned by the specific controller performing the safety function.
- When installing ControlLogix controller, refer to the user manual listed in Additional Resources on page 11.
- There are currently separate firmware revisions for standard and redundant operation. For more information, see Appendix B and the Revision Release List available at http://www.ab.com from the Product Certifications link.

For more information on the ControlLogix controllers, see the publications listed in the Additional Resources on page 11.

ControlLogix Chassis

The ControlLogix 1756-A*xx* chassis provide the physical connections between controllers and I/O modules. The chassis itself is passive and is not relevant to the safety discussion because any physical failure would be unlikely under normal environmental conditions and would be manifested and detected as a failure within one or more of the active components.

When installing ControlLogix chassis, follow the instructions provided in the product documentation.

ControlLogix Power Supplies

ControlLogix power supplies are certified for use in SIL 2 applications. No extra configuration or wiring is required for SIL 2 operation of the ControlLogix power supplies. If an anomaly occurs in the supplied voltages, the power supply immediately shuts down.

All ControlLogix power supplies are designed to perform these tasks:

- Detect anomalies.
- Communicate to the controllers with enough stored power to allow for an orderly and deterministic shutdown of the system, including the controller and I/O modules.

IMPORTANT If you are using any of the 1756-P*x*75 power supplies, with a 1756-L6*x*/B or 1756-L7*x*/B controller, you must use the Series B version of the nonredundant power supplies, that is, 1756-P*x*75/B power supplies.

Redundant Power Supplies

ControlLogix redundant power supplies can be used in SIL 2-certified applications. In a redundant power supply configuration, two power supplies are connected to the same chassis.

The power supplies share the current load required by the chassis and an internal solid state relay that can annunciate a fault. Upon detection of a failure in one supply, the other redundant power supply automatically assumes the full current load required by the chassis without disruption to installed devices.

The 1756-PSCA and 1756-PSCA2 redundant power supply chassis adapter modules connect the redundant power supply to the chassis.

Recommendations for Using Power Supplies

When using SIL 2-certified ControlLogix power supplies:

- follow the information provided in the product's installation instructions.
- wire the solid-state fault relay on each power supply from an appropriate voltage source to an input point in the ControlLogix system so that the application program can detect faults and react appropriately based on the your application requirements.

For more information about installing ControlLogix chassis and power supplies, see the publications listed in Additional Resources on page 11.

ControlLogix Communication Modules

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DeviceNet Scanner Module	45
Data Highway Plus - Remote I/O Module (1756-DHRIO)	45
SynchLink Module	45
General Requirements for Communication Networks	46
Peer-to-Peer Communication Requirements	46
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Introduction to Communication Modules

The communication modules in a SIL 2-certified ControlLogix system provide communication bridges from a ControlLogix chassis to other chassis or devices via the ControlNet and Ethernet networks. These communication modules are available.

Network	SIL 2 Modules(2)	
ControlNet	• 1756-CNB • 1756-CNBR • 1756-CN2	• 1756-CN2R • 1756-CN2RXT
EtherNet/IP	• 1756-ENBT, series A(1) • 1756-EN2T, series C • 1756-EN2T, series D(1) • 1756-EN2TXT, series C • 1756-EN2TXT, series D(1)	• 1756-EN2TR, series B • 1756-EN2TR, series C • 1756-EN2TRXT, series C • 1756-EN3TR, series B(1)
DeviceNet(1)	1756-DNB	
Data Highway Plus™ – Remote I/O(1)	1756-DHRIO	
SynchLink™(1)	1756-SYNCH	

(1) Not for use in safety functions.

(2) Some catalog numbers have a K suffix. This indicates a version of the product that has conformal coating. These K versions have the same SIL 2 certification as the non-K versions. For more information on which products have conformal coating go to: http://ab.com.rockwellautomation.com/

ControlLogix communication modules can be used in peer-to-peer communication between ControlLogix devices. The communication modules can also be used for expansion of I/O to additional ControlLogix remote I/O chassis.

ControlNet Modules and Components

The ControlNet bridge modules (catalog numbers 1756-CNB, 1756-CNBR, 1756-CN2, 1756-CN2R, and 1756-CN2RXT) provide communication between any nodes properly scheduled on the ControlNet network.

ControlNet Cabling

For remote racks, a single RG6 coax cable is required for ControlNet communication. Although it is not a requirement to use redundant media with the 1756-CNBR or 1756-CN2R modules, it does provide higher system reliability. Redundant media is not required for SIL 2 operation.

ControlNet Repeater

The following ControlNet repeater modules are approved for use in safety applications up to and including SIL 2:

- 1786-RPCD, ControlNet Hub Repeater Module
- 1786-RPFS, Short-distance Fiber Repeater Module
- 1786-RPFM, Medium-distance Fiber Repeater Module
- 1786-RPFRL, Long-distance Fiber Repeater Module
- 1786-RPFRXL, Extra-long-distance Fiber Repeater Module

Use of the 1786-RPA adapter is required with all of the repeater modules listed.

Table 2 - For More Information About Repeater Modules

Topic	Publication Title	Publication Number
Planning for and installing ControlNet repeater modules.	ControlNet Fiber Media Planning and Installation Guide	CNET-IN001
Use of repeaters in safety applications.	TÜV Report 968/EZ	968/EX 135.06.12

ControlNet Module Diagnostic Coverage

All communication over the passive ControlNet media occur via CIP, which verifies that at least one valid packet is seen during the greater of either 100 ms or 4 times the requested packet interval (RPI). If a valid packet is not seen during this period, data transitions to the safe state.

EtherNet/IP Communication Modules

Use an EtherNet/IP communication module (catalog numbers 1756-EN2T, 1756-EN2TR, and 1756-EN2TXT) to:

- connect controller chassis to remote I/O.
- make connections for visualization purposes.
- establish connections between the programming terminal and controller.

IMPORTANT Use of a 1756-EN2TR or 1756-EN2TRXT is required to achieve SIL 2 in your application. See Figure 3 on page 18 for an example.

See the examples in Figure 5 on page 19, Figure 6 on page 20, and Figure 12 on page 26.

DeviceNet Scanner Module

The 1756-DNB scanner module connects the controller to devices on a DeviceNet™ network. You can use the 1756-DNB module to communicate only nonsafety data to devices outside of the safety loop.

Data Highway Plus - Remote I/O Module (1756-DHRIO)

The 1756-DHRIO module supports both Data Highway Plus™ and the Remote I/O network of communication. You can use the 1756-DHRIO module to communicate only nonsafety data to devices outside of the safety loop. For example it may be used to communicate alarms to the Distributed Control System (DCS).

SynchLink Module

The SynchLink™ module (catalog number 1756-SYNCH) is used for CST time propagation between multiple chassis for event recording. The module can be used only outside of the safety loop. It must not be used for any safety-related activity in a SIL 2-certified ControlLogix system.

General Requirements for Communication Networks

Follow these requirements when using SIL 2-certified communication modules:

- When installing ControlLogix communication modules, carefully follow the information provided in the module's installation instructions.
- DH+ can be used for communication to Human-to-Machine Interfaces (HMI) and for communicating with the nonsafety portion of the system. For more information on using HMI, see Chapter 9, Use of Human-to-Machine Interfaces on page 103.
- For controllers that are not part of the SIL 2 safety function, use listen-only connections to monitor SIL 2 I/O modules.
- You must not use the Quick Connect feature when using a Ethernet communication for SIL 2 safety I/O.
- Only SIL 2 devices or other devices that provide non-interference should write to SIL 2 controllers The only exception to this is the use of HMI devices. For more information on how to use HMI in the safety loop, see Chapter 9, Use of Human-to-Machine Interfaces on page 103.

Peer-to-Peer Communication Requirements

Peer-to-peer communication via a ControlNet or EtherNet/IP network is permitted when these requirements are met:

- Non-SIL 2 controllers can read data from SIL 2 controllers by directly reading the data via a message instruction, or by consuming data from a SIL 2 controller that is configured to produce data.
- Controllers within the safety loop can be configured to:
  - consume safety data from other safety controllers within the safety loop.

    IMPORTANT Always monitor connection status when consuming safety data from another controller. Use this connection status to take appropriate safety action, if necessary.

  - consume non-safety data from outside the safety loop, such as a reset signal.
  - produce data to controllers outside the safety loop by using a write message (MSG) or produced connections.
- Programming that verifies the correct reception of data must be used.

- Use of a device-level ring (DLR) is required to produce and consume SIL 2 data on an EtherNet/IP network. If you are not using the ring capability of the 1756-EN2TR when producing or consuming SIL 2 safety data on an EtherNet/IP network, you must use two independent data paths between the SIL 2 devices. For example, to exchange SIL 2 data between two ControlLogix SIL 2 controllers, you could use two produced connections sending data to two consume connections. Each controller produces data to the other.

Additional Resources

This table lists additional resources specific to the ControlLogix communication modules.

Cat. No.	Module Description	User Manual
1756-CNB 1756-CN2	ControlNet Communication Module	CNET-UM001
1756-CNBR 1756-CN2R	Redundant ControlNet Communication Module	
1756-DHRIO	Data Highway Plus - Remote I/O Communication Interface Module	1756-UM514
1756-DNB	DeviceNet Scanner Module	DNET-UM004
1756-ENBT 1756-EN2T 1756-EN2TR 1756-EN3TR 1756-EN2TRXT 1756-EN2TXT	Ethernet Communication Module	ENET-UM001
1756-RM 1756-RM2	Redundancy Module	1756-UM535
1756-SYNCH	SynchLink Module	1756-UM521

You can view or download Rockwell Automation publications at http://www.rockwellautomation.com/literature/.

Notes:

ControlLogix I/O Modules

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IMPORTANT The programming information and examples in this chapter are provided to illustrate diagnostic and other logic-related principles that must be demonstrated in SIL 2 application programs.

The principles and logic shown in this chapter can be encased in Add-On Instructions for easier use.

If you are using a duplex configuration and certain I/O termination boards, the programming explained in this chapter is available in Add-On Instructions. These Add-On Instructions are certified by TÜV.

Refer to ControlLogix SIL 2 System Configuration Using SIL 2 Add-On Instructions, publication 1756-AT012 for more information.

Overview of ControlLogix I/O Modules

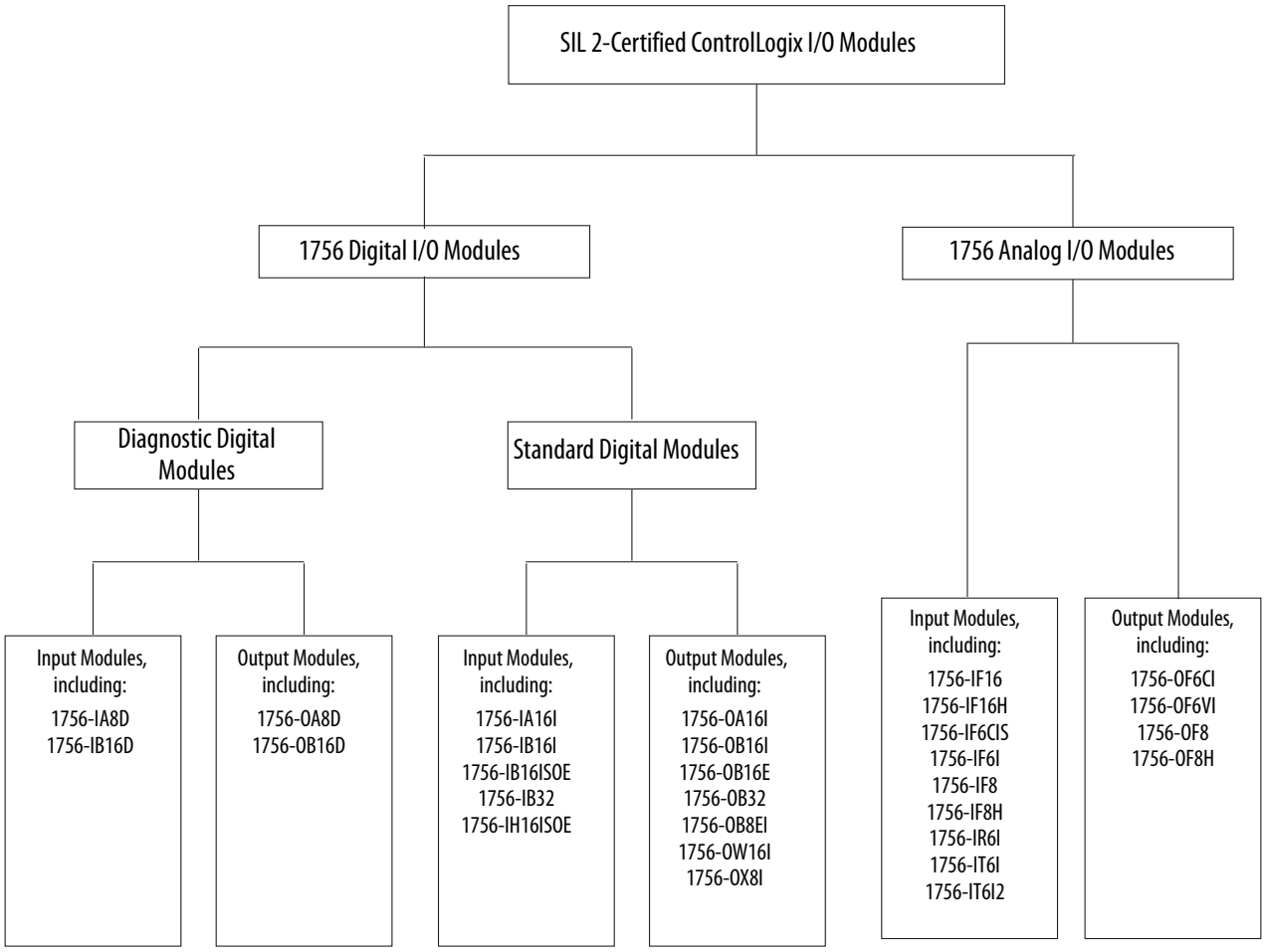
At the most basic level, there are two types of SIL 2-certified ControlLogix I/O modules:

- Digital I/O modules
- Analog I/O modules

With each type, however, there are differences between specific modules. Because the differences propagate to varying levels in each module type, a graphical representation can best provide an overview of the many SIL 2-certified ControlLogix I/O modules.

This figure shows the SIL 2-certified ControlLogix I/O modules. Each type, digital or analog, is described in greater detail throughout the rest of this chapter.

Figure 17 - Types of SIL 2-certified I/O Modules



IMPORTANT: Some catalog numbers have a K suffix. This indicates a version of the product that has conformal coating. These K versions have the same SIL 2 certification as the non-K versions. For more information on which products have conformal coating go to: http://ab.com.rockwellautomation.com/

For SIL 2 compliance when installing ControlLogix I/O modules, follow the procedures provided in the module's installation instructions. For a full list of installation instructions for SIL 2-certified modules, see Appendix B.

Using 1756 Digital Input Modules

To achieve SIL 2, two digital input modules must be used, with field sensors wired to channels on each module. The two channels must be compared by software before reconciling the data.

ControlLogix digital input modules are divided into two categories:

- Diagnostic input modules
- Standard input modules

These modules share many of the same inherent architectural characteristics. However, the diagnostic input modules incorporate features that allow diagnosing of field-side failures. These features include broken-wire (that is, wire-off) detection and, in the case of AC Diagnostic modules, loss of line power.

Requirements When Using Any ControlLogix Digital Input Module

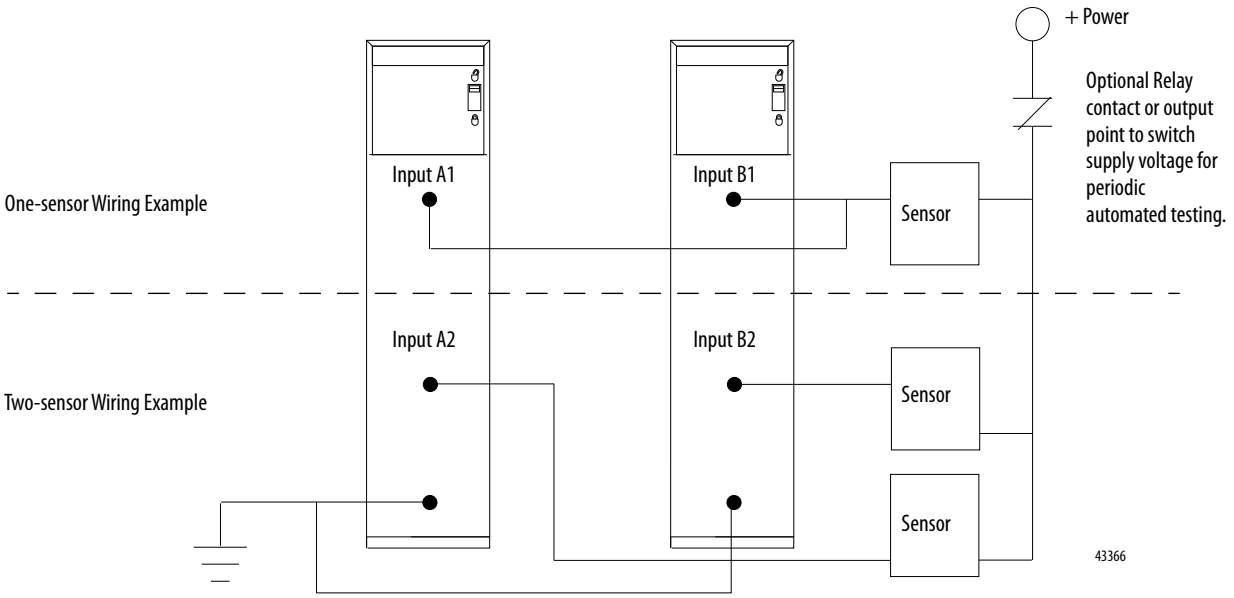
Regardless of the type of ControlLogix input module used, you must follow these general application requirements when applying these modules in a SIL 2 application:

- **Ownership** – The same controller must own both modules.
- **Direct connection** – Always use a direct connection with any SIL 2 CL modules. You must not use rack optimized connections in a SIL 2 application.
- **Separate input points** – Wire sensors to separate input points on two separate modules. The use of two digital input modules is required, regardless of the number of field sensors.
- **Field device testing** – Test field devices by cycling them. The closer you can get to the device being monitored to perform the test, the more comprehensive the test will be.
- **Proof tests** – Periodically perform a system validation test. Manually or automatically test all inputs to make sure they are operational and not stuck in the ON or OFF state. Inputs must be cycled from ON to OFF or OFF to ON. For more information, see Proof Tests on page 28.

Wiring ControlLogix Digital Input Modules

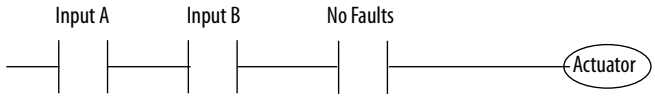
This diagram shows two examples of wiring digital inputs. In either case, the type of sensors being used will determine whether the use of 1 or 2 sensors is appropriate to fulfill SIL 2 requirements.

Figure 18 - ControlLogix Digital Input Module Wiring Example



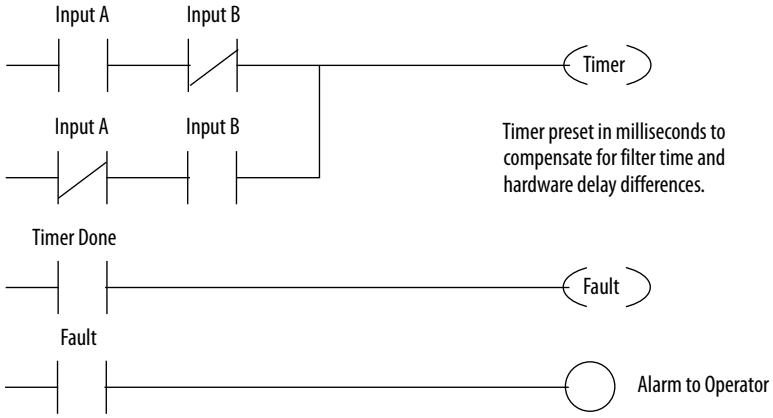
Application logic is used to compare input values for concurrence.

Figure 19 - Logic Comparing Input Values or States



The user program must also contain rungs to annunciate a fault in the event of a sustained miscompare between two points.

Figure 20 - Rungs Annunciating a Fault



The control, diagnostics and alarming functions must be performed in sequence. For more information on faults, see Chapter 8, Faults in the ControlLogix System.

Using 1756 Digital Output Modules

ControlLogix digital output modules are divided into two categories:

- Diagnostic output modules
- Standard output modules

These modules share many of the same inherent architectural characteristics. However, the diagnostic output modules incorporate features that allow diagnosing of field-side failures, including:

- No-Load (loss of load) reporting.
- Blown Fuse reporting.
- Output verify.
- Output pulse test.

To achieve SIL 2, a standard output module must be wired back to an input module for monitoring. Diagnostic digital output modules provide their own monitoring.

Requirements When Using ControlLogix Digital Output Modules

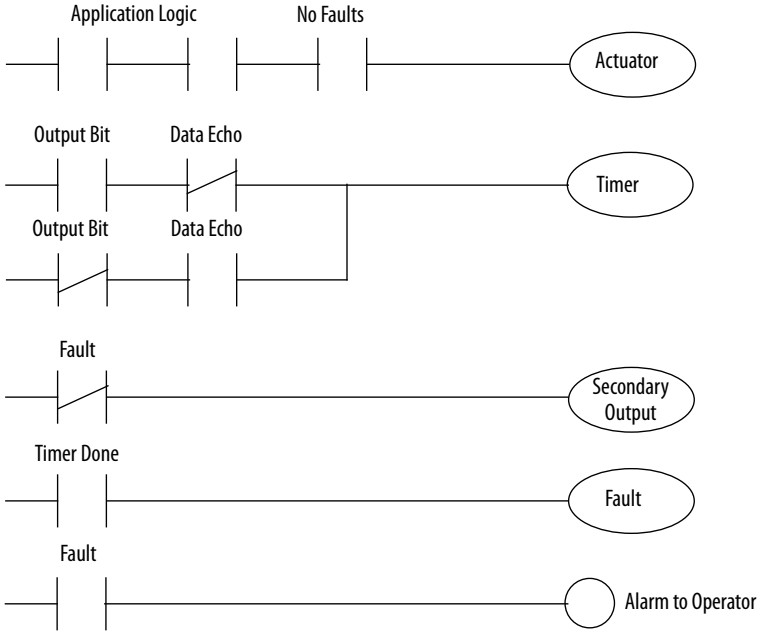
Wiring the two types of digital output modules differs, depending on your application requirements (these wiring methods are explained in detail in later sections). However, regardless of the type of ControlLogix output module used, you must follow these general application requirements when applying these modules in a SIL 2 application:

- **Proof tests -** Periodically perform a system validation test. Manually or automatically test all outputs to make sure that they are operational and not stuck in the ON or OFF state. Outputs must be cycled from ON to OFF or OFF to ON. For more information, see Proof Tests on page 28.

- **Examination of output data echo signal in application logic** – The application logic must examine the Data Echo value associated with each output point to make sure that the requested ON/OFF command from the controller was received and acted upon by the module.

  In Figure 21, a timer begins to increment for any miscompare between the controller's output and the module's Data Echo feedback. The discrepancy timer must be set to accommodate the delay between the controller output data and the module's Data Echo response. The time value chosen needs to consider various system RPIs and network latency. If a miscompare exists for longer than that time, a fault bit is set.

Figure 21 - Data Echo Discrepancy Timer Logic



The control, diagnostics and alarming functions must be performed in sequence. For more information on faults, see Chapter 8, Faults in the ControlLogix System.

- **Use of external relays to disconnect module power if output de-energized state is critical**. To verify that outputs will de-energize, users must wire an external relay or other measure, that can remove power from the output module if a short or other fault is detected. See Figure 22 on page 55 for an example method of wiring an external relay.

- **Test outputs at specific times to make sure they are operating properly**. The method and frequency of testing is determined by the requirements of the safety application. For more information on testing diagnostic module outputs, see page 54. For more information on testing standard module outputs, see page 56.

- **For typical emergency shutdown (ESD) application outputs must be configured to de-energize**: When configuring any ControlLogix output module, each output must be configured to de-energize in the event of a fault and in the event of the controller going into Program mode. For exceptions to the typical ESD applications, see Chapter 1, SIL Policy on page 13.

- When wiring two digital output modules in series so that one may break source voltage (as shown in Figure 26 on page 57), one controller must own both modules.

Wiring ControlLogix Digital Output Modules

Diagnostic digital output modules and standard output modules have different wiring considerations. Reference the module-type considerations that apply to your system configuration.

Wiring Diagnostic Digital Output Modules

Diagnostic output modules have circuitry that is not included in standard output modules. Because of this feature, you are not required to use an input module to monitor output status, as is required with standard output modules.

Diagnostic output modules can be used as-is in a SIL 2 application. No special wiring considerations need be employed other than the wiring of the external relay or other measures to remove line power from the module in the event of a fault to make sure outputs will de-energize if shorted.

In addition to referencing the Requirements When Using ControlLogix Digital Output Modules on page 53 for limited high demand applications, testing of output modules (that is, the user turns the outputs ON and OFF to verify proper operation) should be executed once every eight hours. Note that high demand applications are limited to 10 demands per year for ControlLogix SIL 2 systems.

For more information on performing the pulse test, see the ControlLogix Digital I/O Modules User Manual, publication 1756-UM058.

Figure 22 - ControlLogix Diagnostic Output Module Wiring

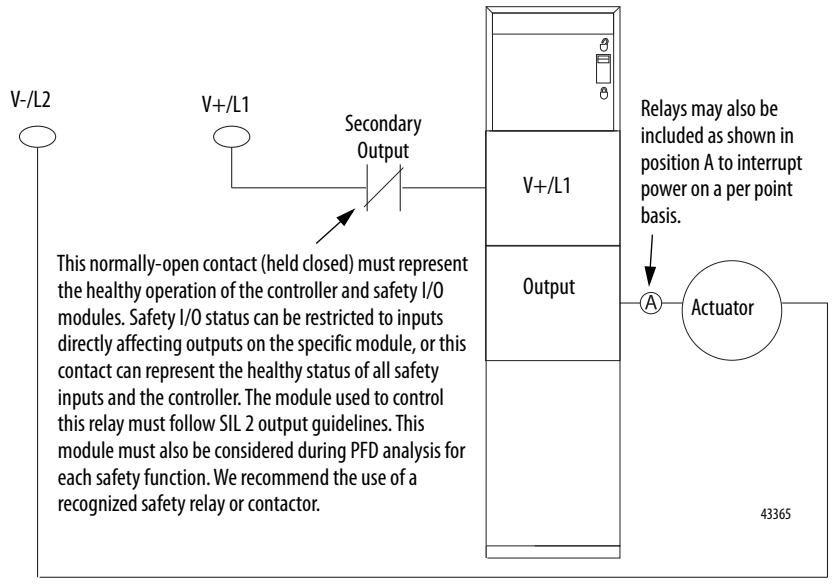
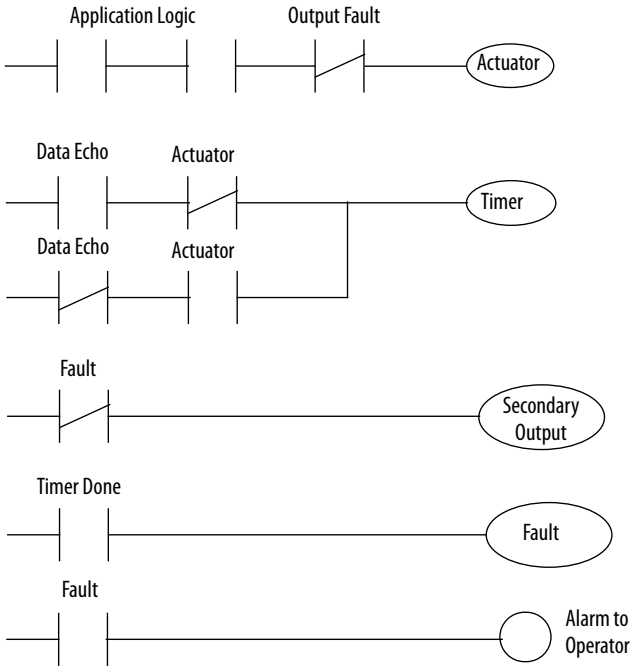

V-/L2
V+/L1
Secondary Output
V+/L1
Output
Relays may also be included as shown in position A to interrupt power on a per point basis.
A
Actuator
This normally-open contact (held closed) must represent the healthy operation of the controller and safety I/O modules. Safety I/O status can be restricted to inputs directly affecting outputs on the specific module, or this contact can represent the healthy status of all safety inputs and the controller. The module used to control this relay must follow SIL 2 output guidelines. This module must also be considered during PFD analysis for each safety function. We recommend the use of a recognized safety relay or contactor.
43365

Figure 23 - Diagnostic Output Logic



Output Fault contact must represent module and channel diagnostics.

Wiring Standard Digital Output Modules

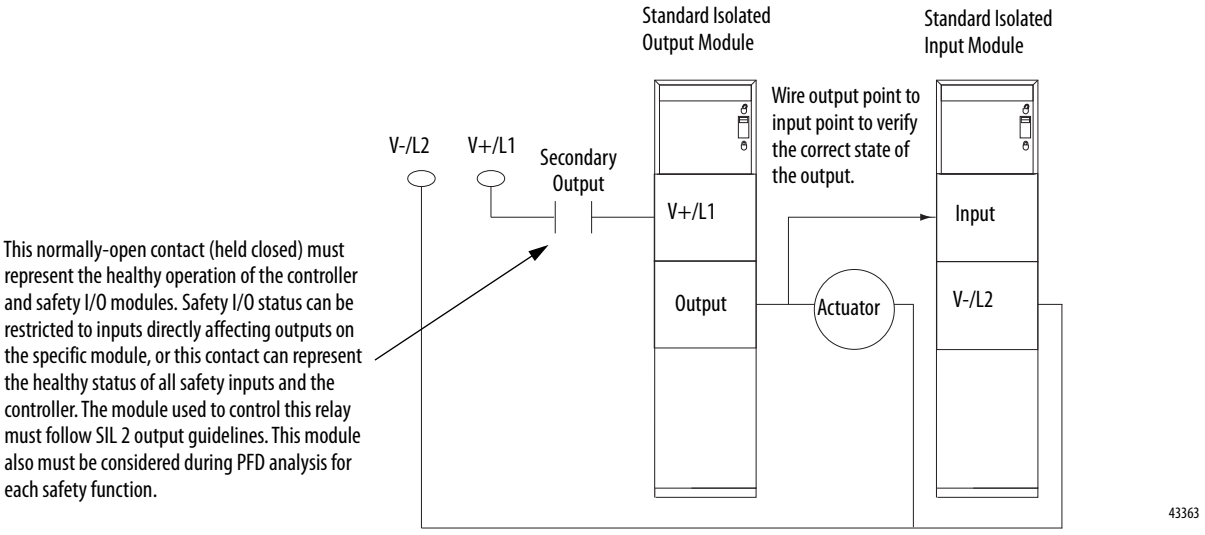
When using standard (non-diagnostic) output modules, you must wire each output to its field device and also to a system input to monitor the output's performance. To verify output performance, use one of these methods:

- Write logic to test the output's ability to turn ON and OFF at power-up.
- At the proof test interval, force the output ON and OFF and use a voltmeter to verify output performance.

For limited high demand applications, testing of output modules (that is, the user turns the outputs ON and OFF to verify proper operation) should be executed once every eight hours. Note that high demand applications are limited to 10 demands per year for ControlLogix SIL 2 systems.

See Requirements When Using ControlLogix Digital Output Modules on page 53.

Figure 24 - ControlLogix Standard Output Module Wiring


Standard Isolated Output Module
Standard Isolated Input Module
Wire output point to input point to verify the correct state of the output.
V-/L2
V+/L1
Secondary Output
V+/L1
Output
Actuator
Input
V-/L2
This normally-open contact (held closed) must represent the healthy operation of the controller and safety I/O modules. Safety I/O status can be restricted to inputs directly affecting outputs on the specific module, or this contact can represent the healthy status of all safety inputs and the controller. The module used to control this relay must follow SIL 2 output guidelines. This module also must be considered during PFD analysis for each safety function.
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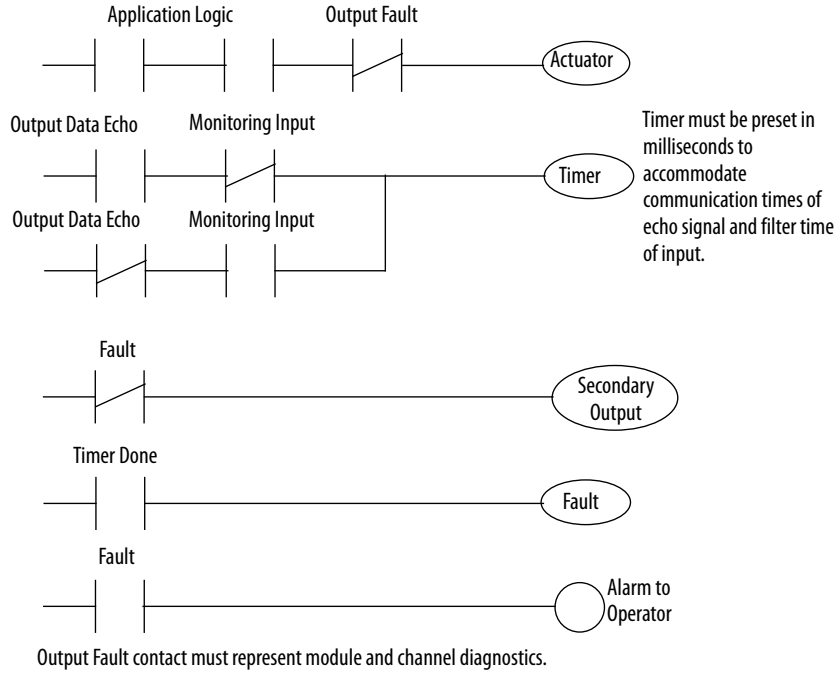
Write the application logic to generate a fault in the event of a miscompare between the controller, the actual output state, and the monitored input.

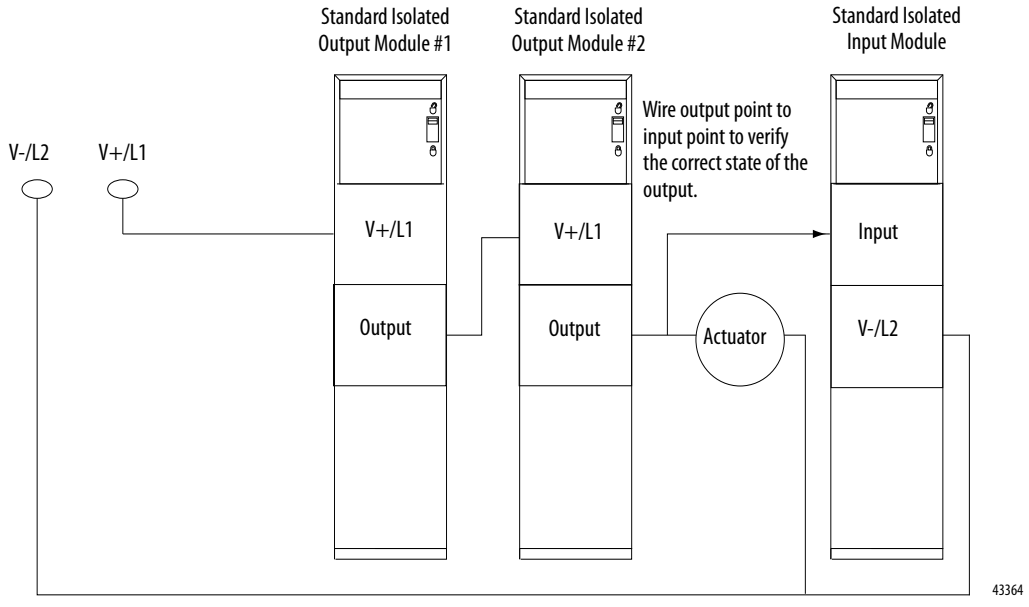
Figure 25 - Comparison Logic for Requested versus Actual Output



The control, diagnostics, and alarming functions must be performed in sequence. For more information on faults, see Chapter 8, Faults in the ControlLogix System on page 99.

You can also wire two isolated, standard outputs in series to critical actuators. In the event that a failure is detected, the outputs from each of the output modules must be set to OFF to make sure the field devices de-energize. Figure 26 shows how to wire two isolated, standard outputs in series to critical actuators.

Figure 26 - ControlLogix Standard Output Module Wiring with Two Modules



Using 1756 Analog Input Modules

There are a number of general application considerations that you must make when using analog input modules in a SIL 2 application. The following section describes those considerations specific to the use of analog input modules.

To achieve SIL 2, two analog input modules are required. Field sensors must be wired to channels on each module and compared within a deadband. Whether one or two field sensors are required is dependent on the Probability of Failure on Demand (PFD) value of the sensor.

Conduct Proof Tests

Periodically perform a system validation test. Manually or automatically test all inputs to make sure that they are operational. Field signal levels should be varied over the full operating range to make sure that the corresponding channel data varies accordingly. For more information, see Proof Tests on page 28.

Calibrate Inputs

Analog input modules should be calibrated periodically, as their use and application requires. ControlLogix I/O modules ship from the factory with a highly accurate level of calibration. However, because each application is different, you are responsible for making sure your ControlLogix I/O modules are properly calibrated for your specific application.

You can employ tests in application program logic to determine when a module requires recalibration. For example, to determine whether an input module needs to be recalibrated, you can determine a tolerance band of accuracy for a specific application. You can then measure input values on multiple channels and compare those values to acceptable values within the tolerance band. Based on the differences in the comparison, you could then determine whether recalibration is necessary.

Calibration (and subsequent recalibration) is not a safety issue. However, we recommend that each analog input be calibrated at least every three years to verify the accuracy of the input signal and avoid nuisance application shutdowns.

Use the Floating Point Data Format

ControlLogix analog input modules perform on-board alarm processing to validate that the input signal is within the proper range. These features are only available in Floating Point mode. To use the Floating Point Data format, select the Floating Point Data format in the Module Properties dialog box.

Program to Respond to Faults Appropriately

When programming the SIL 2 system, verify that your program examines the appropriate module fault, channel fault, and channel status bits and responds by initiating the appropriate fault routine.

Each module communicates the operating status of each channel to the controller during normal operation. Application logic must examine the appropriate bits to initiate a fault routine for a given application. For more information on faults, see Chapter 8, Faults in the ControlLogix System on page 99.

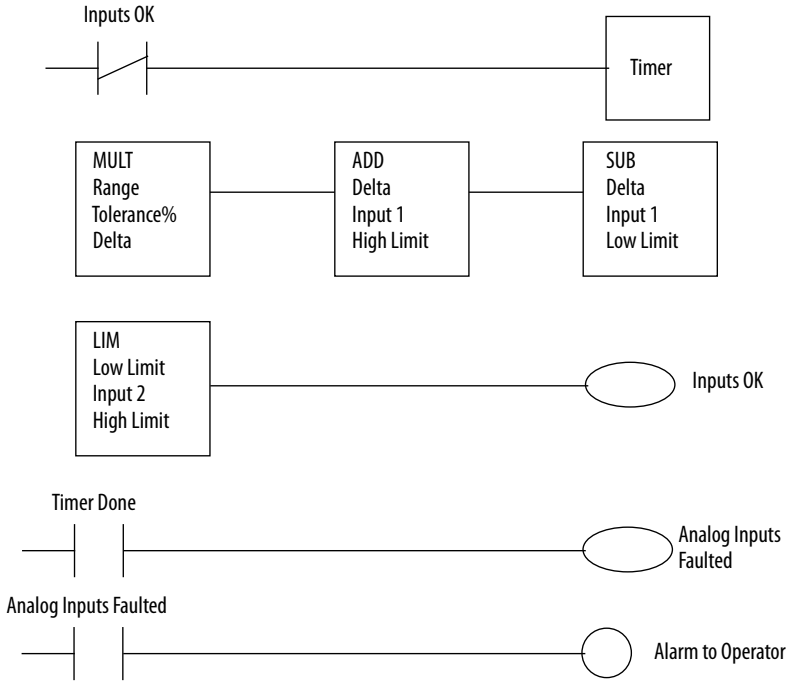
Program to Compare Analog Input Data

When wiring sensors to two input channels on different modules, the values from those channels must be compared to each other within the program for concurrence within an acceptable range for the application, before an output is actuated. Any miscompare between the two inputs outside the programmed acceptable range must be annunciated as a fault.

In Figure 27, a user-defined percentage of acceptable deviation (that is, tolerance) is applied to the configured input range of the analog inputs (that is, range) and the result is stored (that is, delta). This delta value is then added to and subtracted from one of the input channels; the results define an acceptable High and Low limit of deviation. The second input channel is then compared to these limits to determine if the inputs are working properly.

The input's OK bit preconditions a Timer run that is preset to accommodate an acceptable fault response time and any communication filtering lags in the system. If the inputs miscompare for longer than the preset value, a fault is registered with a corresponding alarm.

Figure 27 - Comparison Logic for Two Analog Inputs



The control, diagnostics and alarming functions must be performed in sequence. For more information on faults, see Chapter 8, Faults in the ControlLogix System on page 99.

Configure Modules

When using identical modules, configure the modules identically, that is, by using the same RPI, filter values, and so on.

When using different modules for improved diversity, make sure the module's scaling of data does not introduce error or fault conditions.

Specify the Same Controller as the Owner

The same controller must own both analog input modules.

You must use Analog Inputs Faulted as a safety status/permissive in respective safety-related outputs.

Wiring ControlLogix Analog Input Modules

The wiring diagrams shown in this section apply to applications requiring two transmitters. The type of transmitter along with the application requirements will determine whether one or two transmitters are required.

In general, good design practice dictates that each of the two transmitters must be wired to input terminals on separate modules such that the channel values may be validated by comparing the two within an acceptable range. Special consideration must be given in applying this technique, depending on the type of module being used.

Wiring the Single-Ended Input Module in Voltage Mode

Make sure you:

- review the considerations in Using 1756 Analog Input Modules on page 58.
- use the correct documentation (listed in Additional Resources on page 11) to wire the module.
- tie all (-) leads of the transmitters together when operating in single-ended Voltage mode.

Figure 28 shows how to wire an analog input for use in Voltage mode.

Figure 28 - ControlLogix Analog Input Module Wiring in Voltage Mode

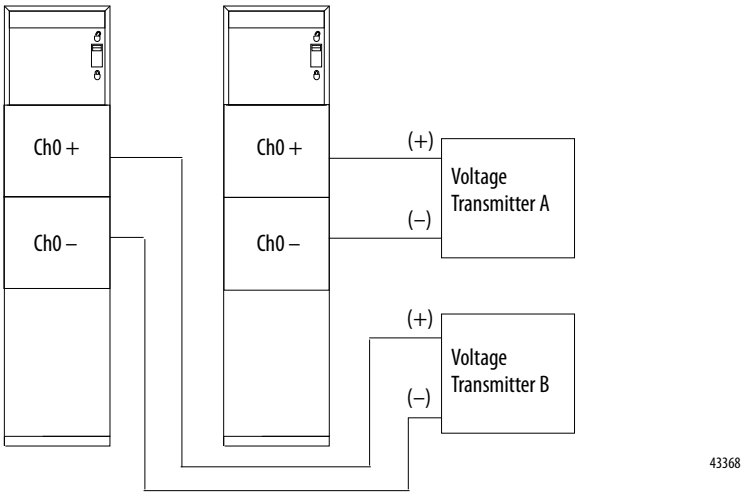


Figure 29 shows how to wire a SIL 2 transmitter to two analog input modules configured for voltage mode.

Figure 29 - ControlLogix Analog Input Module Wiring in Voltage Mode

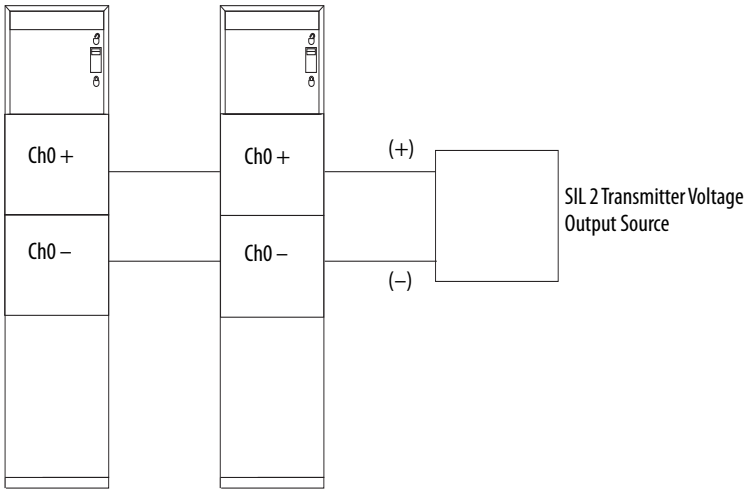
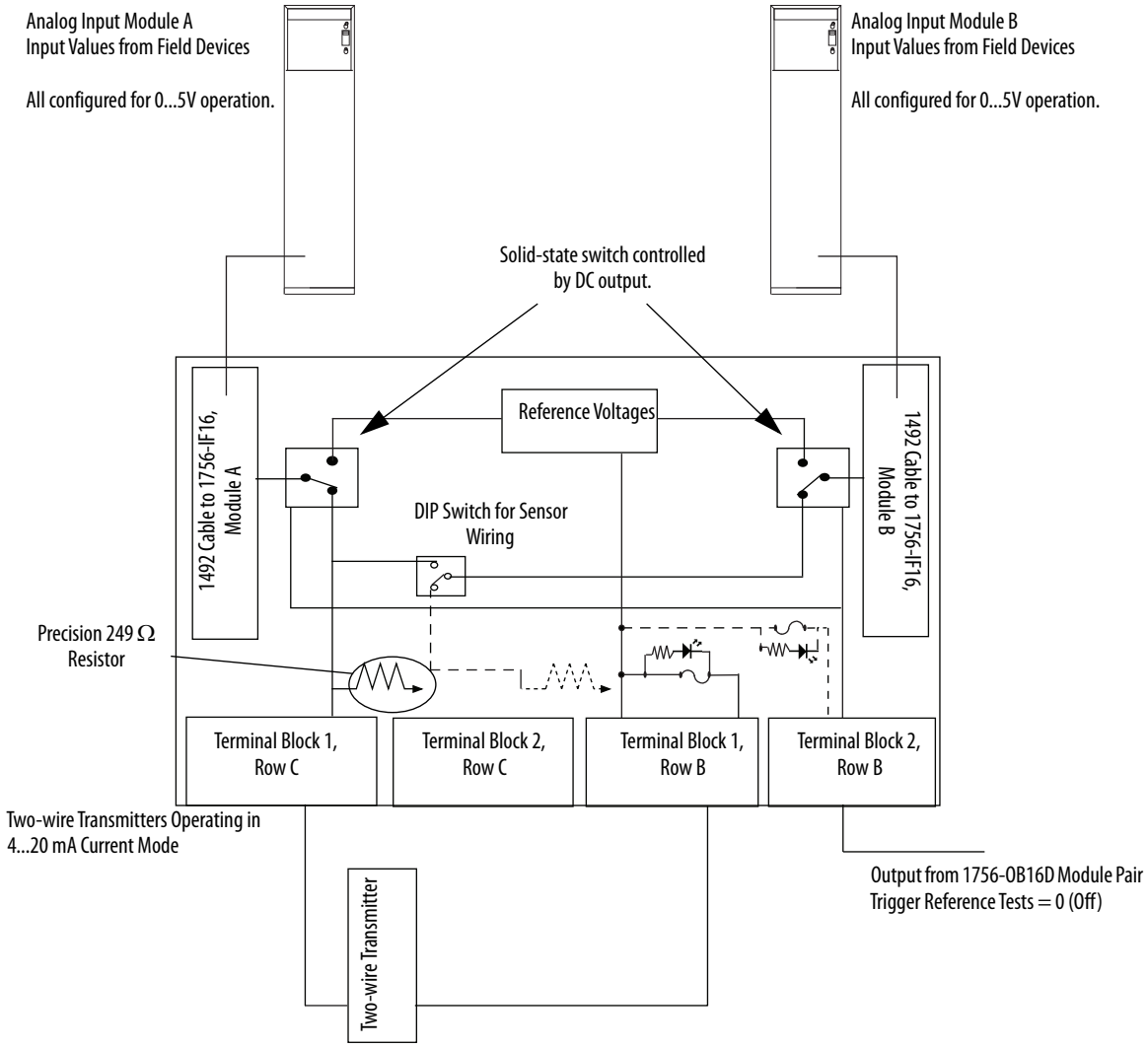


Figure 30 - Analog Input Wiring Example with Termination Boards


Analog Input Module A
Input Values from Field Devices
All configured for 0...5V operation.
Analog Input Module B
Input Values from Field Devices
All configured for 0...5V operation.
Solid-state switch controlled by DC output.
1492 Cable to 1756-IF16, Module A
Reference Voltages
DIP Switch for Sensor Wiring
1492 Cable to 1756-IF16, Module B
Precision 249 Ω Resistor
Terminal Block 1, Row C
Terminal Block 2, Row C
Terminal Block 1, Row B
Terminal Block 2, Row B
Two-wire Transmitters Operating in 4...20 mA Current Mode
Two-wire Transmitter
Output from 1756-OB16D Module Pair
Trigger Reference Tests = 0 (Off)

Wiring the Single-ended Input Module in Current Mode

Make sure you:

- review the considerations in Using 1756 Analog Input Modules on page 58.
- use the correct documentation (listed in Additional Resources on page 11) to wire the module.
- place devices correctly in the current loop. You can locate other devices in an input channel's current loop anywhere as long as the current source can provide sufficient voltage to accommodate all of the voltage drops (each module input is 250 ohms)

Figure 31 and Figure 32 show how to wire an analog input for use in Current mode.

Figure 31 - ControlLogix Analog Input Module Wiring in Current Mode

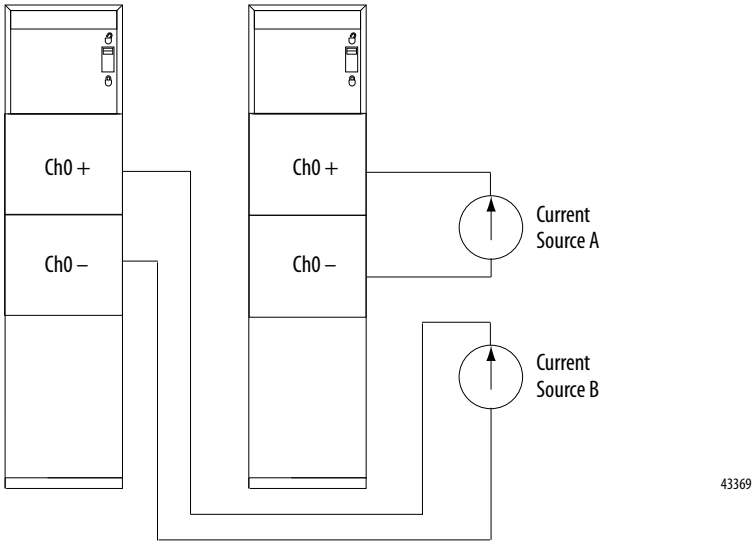
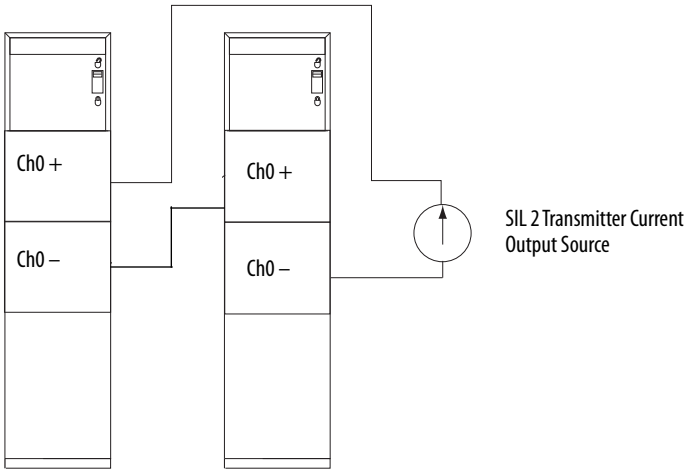


Figure 32 - ControlLogix Analog Input Module Wiring for Isolated Channels (in Current mode)



If you use single-ended channels, use a 1492-TAIFM16-F-3 termination board and two 1492-ACABLE010UA cables to split the current sensor into two single-ended channels configured for Voltage mode.

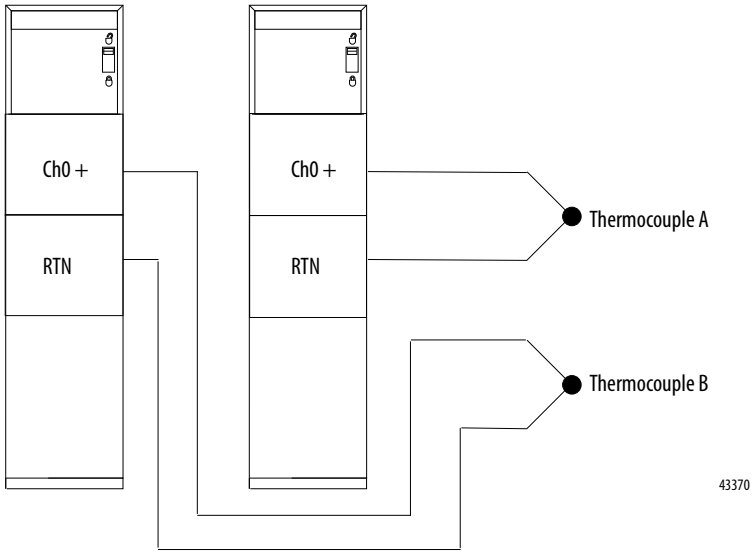
Wiring the Thermocouple Input Module

Make sure you:

- review the considerations in Using 1756 Analog Input Modules on page 58.
- use the correct documentation (listed in Additional Resources on page 11) to wire the module.
- wire to same input channel on both modules. When wiring thermocouples, wire two in parallel to two modules. Use the same channel on each module to make sure of consistent temperature readings.

Figure 33 on page 64 shows how to wire the 1756-IT6I module.

Figure 33 - ControlLogix Analog Thermocouple Module Wiring



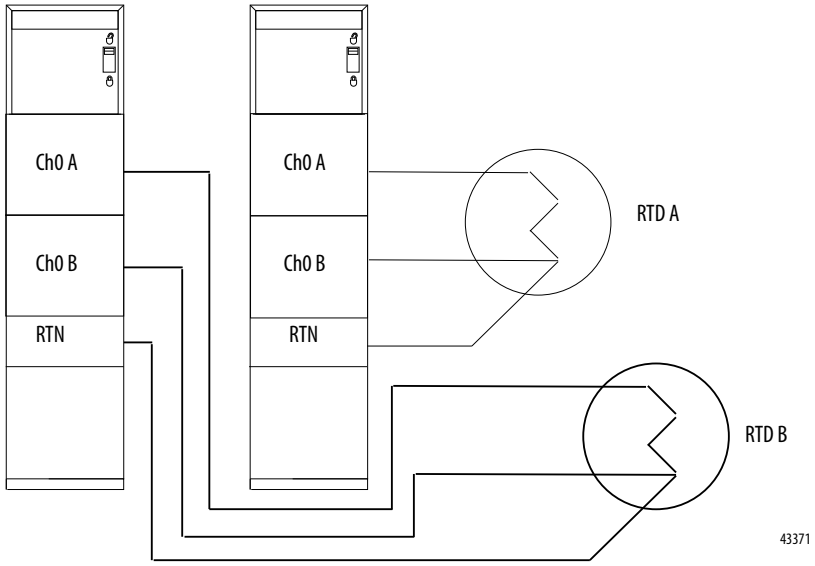
Wiring the RTD Input Module

Make sure you:

- review the considerations in Using 1756 Analog Input Modules on page 58.
- use the correct documentation (listed in Additional Resources on page 11) to wire the module.
- use two sensors. RTDs cannot be wired in parallel without severely affecting their accuracy.

Figure 34 shows how to wire the 1756-IR6I module.

Figure 34 - ControlLogix Analog RTD Module Wiring



Using 1756 HART Analog Input Modules

The Highway Addressable Remote Transducer (HART) analog modules should be used according to the same considerations as other analog input modules.

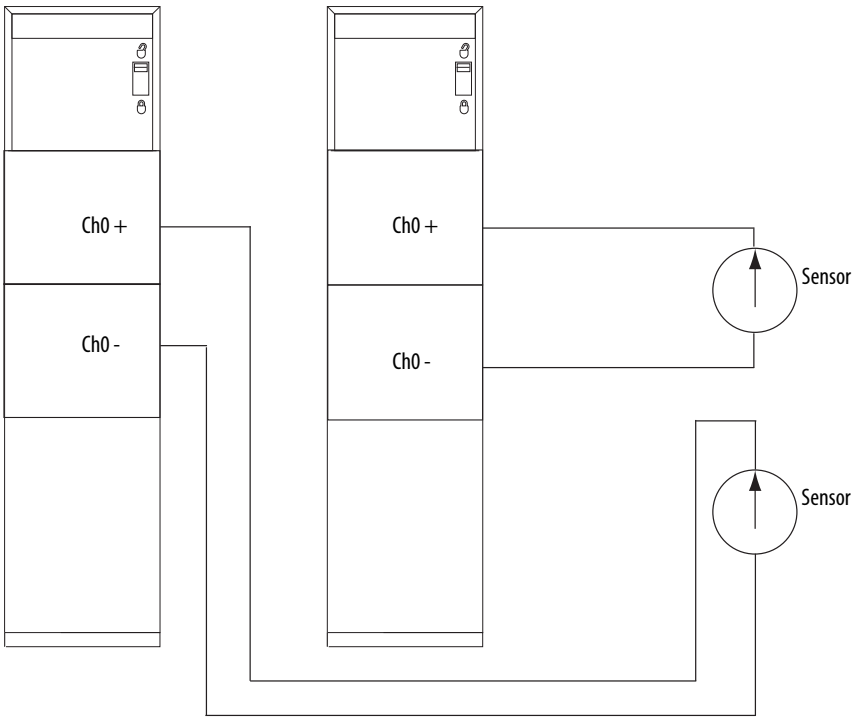
IMPORTANT HART protocol must not be used for safety-related data.

Wiring the HART Analog Input Modules

Make sure you:

- review the considerations in Using 1756 Analog Input Modules on page 58.
- use the correct documentation (listed in Additional Resources on page 11) to wire the module.

Figure 35 - HART Input Analog Module Wiring



Using 1756 Analog Output Modules

There are a number of general application considerations that you must make when using analog output modules in a SIL 2 application.

A single analog output module, along with an analog input module for monitoring is required to achieve SIL 2.

The following sections describe those considerations specific to the use analog output modules.

Considerations for Using Analog Output Modules

IMPORTANT	It is strongly recommended that you do not use analog outputs to execute the safety function that results in a safe state. Analog output modules are slow to respond to an ESD command and are therefore not recommended for use ESD output modules. The use of digital output modules and actuators to achieve the ESD de-energized state is recommended.

Conduct Proof Tests

Periodically perform a system validation test. Manually or automatically test all outputs to make sure that they are operational. Field signal levels should be varied over the full operating range to make sure that the corresponding channel data varies accordingly. For more information, see Proof Tests on page 28.

Calibrate Outputs

Analog output modules should be calibrated periodically, as their use and application requires. ControlLogix I/O modules ship from the factory with a highly accurate level of calibration. However, because each application is different, you are responsible for making sure your ControlLogix I/O modules are properly calibrated for your specific application.

You can employ tests in application program logic to determine when a module requires recalibration. For example, to determine whether an output module needs to be recalibrated, you can determine a tolerance band of accuracy for a specific application. You can then measure output values on multiple channels and compare those values to acceptable values within the tolerance band. Based on the differences in the comparison, you could then determine whether recalibration is necessary.

Calibration (and subsequent recalibration) is not a safety issue. However, we recommend that each analog output be calibrated at least every 3 years to verify the accuracy of the signal and avoid nuisance application shutdowns.

Use the Floating Point Data Format

ControlLogix analog output modules perform on-board alarm processing to validate that the input signal is within the proper range. These features are only available in Floating Point mode. To use the Floating Point Data format, select the Floating Point Data format in the Module Properties dialog box.

Program to Respond to Faults Appropriately

When programming the SIL 2 system, verify that your program examines the appropriate module fault, channel fault, and channel status bits and responds by initiating the appropriate fault routine.

Each module communicates the operating status of each channel to the controller during normal operation. Application logic must examine the appropriate bits to initiate a fault routine for a given application. For more information on faults, see Chapter 8, Faults in the ControlLogix System on page 99.

Configure Outputs to De-energize in ESD Applications

For typical emergency shutdown (ESD) applications, outputs must be configured to de-energize. When configuring any ControlLogix output module, each output must be configured to de-energize in the event of a fault and in the event of the controller going into Program mode. For exceptions to the typical ESD applications, see Chapter 1, SIL Policy on page 13.

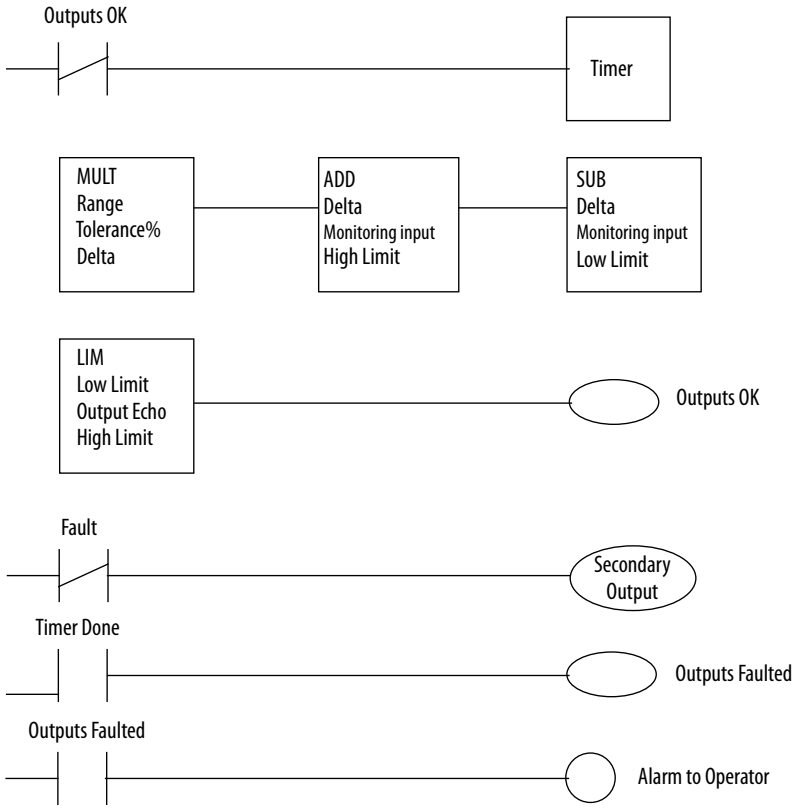
Monitor Channel Status

You must wire each analog output to an actuator and then back to an analog input to monitor the output's performance, as shown in Figure 37. The application logic must examine the analog input (feedback value) associated with each analog output to make sure that the output from the controller was received correctly at the actuator. The analog output value must be compared to the analog input that is monitoring the output to make sure the value is within an acceptable range for the application.

In the ladder diagram in Figure 36, a user-defined percentage of acceptable deviation (that is, tolerance) is applied to the configured range of the analog input and output and the result is stored (that is, delta). This delta value is then added to and subtracted from the monitoring analog input channel; the results define an acceptable high and low limit of deviation. The analog Output Echo is then compared to these limits to determine if the output is working properly.

The output's OK bit preconditions a Timer run that is preset to accommodate an acceptable fault response time and any communication filtering, or output, lags in the system. If the monitoring input value and the Output Echo miscompare for longer than the preset value, a fault is registered with a corresponding alarm.

Figure 36 - Monitoring an Analog Output with an Analog Input



The control, diagnostics, and alarming functions must be performed in sequence.

Specify the Same Controller as the Owner

The same controller must own both analog modules.

Wiring ControlLogix Analog Output Modules

In general, good design practice dictates that each analog output must be wired to a separate input terminal to make sure that the output is functioning properly.

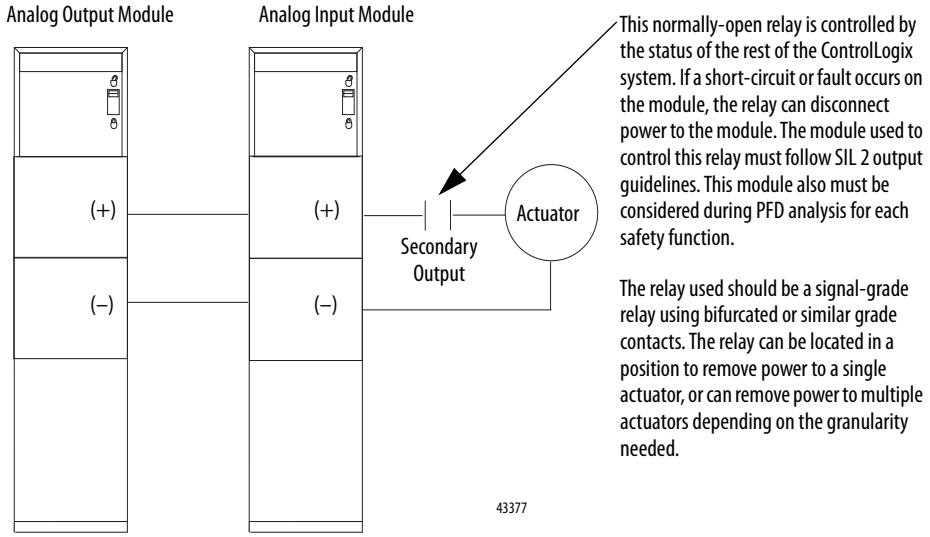
Wiring the Analog Output Module in Voltage Mode

Make sure you:

- review the considerations in Considerations for Using Analog Output Modules on page 67.
- Use the correct documentation (listed in Additional Resources on page 11) to wire the module.

Figure 37 shows how to wire the 1756-OF8 module for use in Voltage mode.

Figure 37 - ControlLogix Analog Output Module Wiring in Voltage Mode


Analog Output Module
Analog Input Module
(+)
(–)
(+)
(–)
Actuator
Secondary
Output
43377
This normally-open relay is controlled by the status of the rest of the ControlLogix system. If a short-circuit or fault occurs on the module, the relay can disconnect power to the module. The module used to control this relay must follow SIL 2 output guidelines. This module also must be considered during PFD analysis for each safety function.
The relay used should be a signal-grade relay using bifurcated or similar grade contacts. The relay can be located in a position to remove power to a single actuator, or can remove power to multiple actuators depending on the granularity needed.

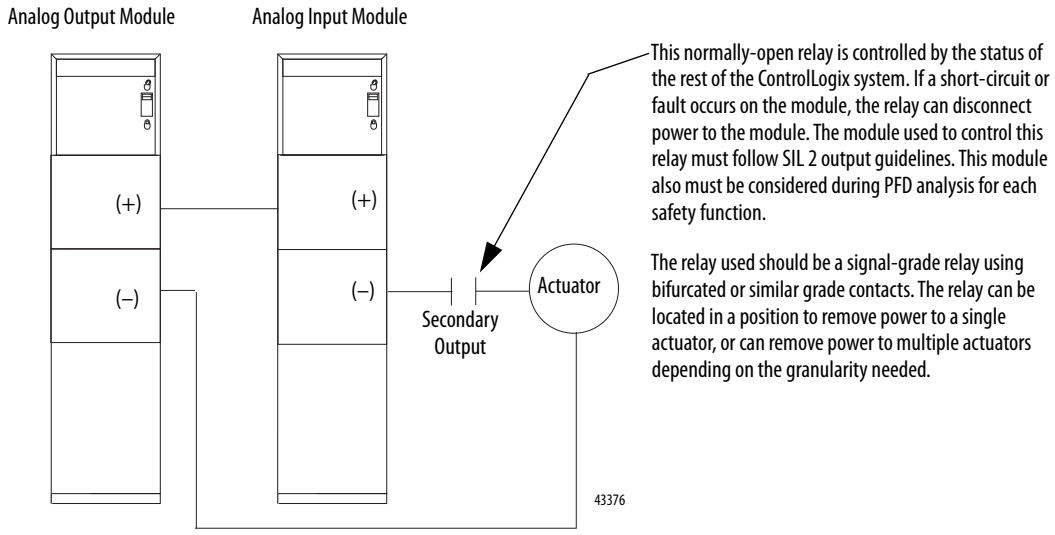
Wiring the Analog Output Module in Current Mode

Make sure you:

- review the considerations in Considerations for Using Analog Output Modules on page 67.
- use the correct documentation (listed in Additional Resources on page 11) to wire the module.
- place devices correctly in the current loop. You can locate other devices in an output channel's current loop anywhere as long as the current source can provide sufficient voltage to accommodate all of the voltage drops (each module output is 250 Ω).

Figure 38 shows how to wire the 1756-OF8 module for use in Current mode.

Figure 38 - ControlLogix Analog Output Module Wiring in Current Mode


Analog Output Module
Analog Input Module
(+)
(–)
(+)
(–)
Actuator
Secondary
Output
43376
This normally-open relay is controlled by the status of the rest of the ControlLogix system. If a short-circuit or fault occurs on the module, the relay can disconnect power to the module. The module used to control this relay must follow SIL 2 output guidelines. This module also must be considered during PFD analysis for each safety function.
The relay used should be a signal-grade relay using bifurcated or similar grade contacts. The relay can be located in a position to remove power to a single actuator, or can remove power to multiple actuators depending on the granularity needed.

Using 1756 HART Analog Output Modules

The Highway Addressable Remote Transducer (HART) analog modules should be used according to the same considerations as other analog output modules. For an illustration of how to wire the HART analog output modules, see Wiring the HART Analog Output Modules on page 71.

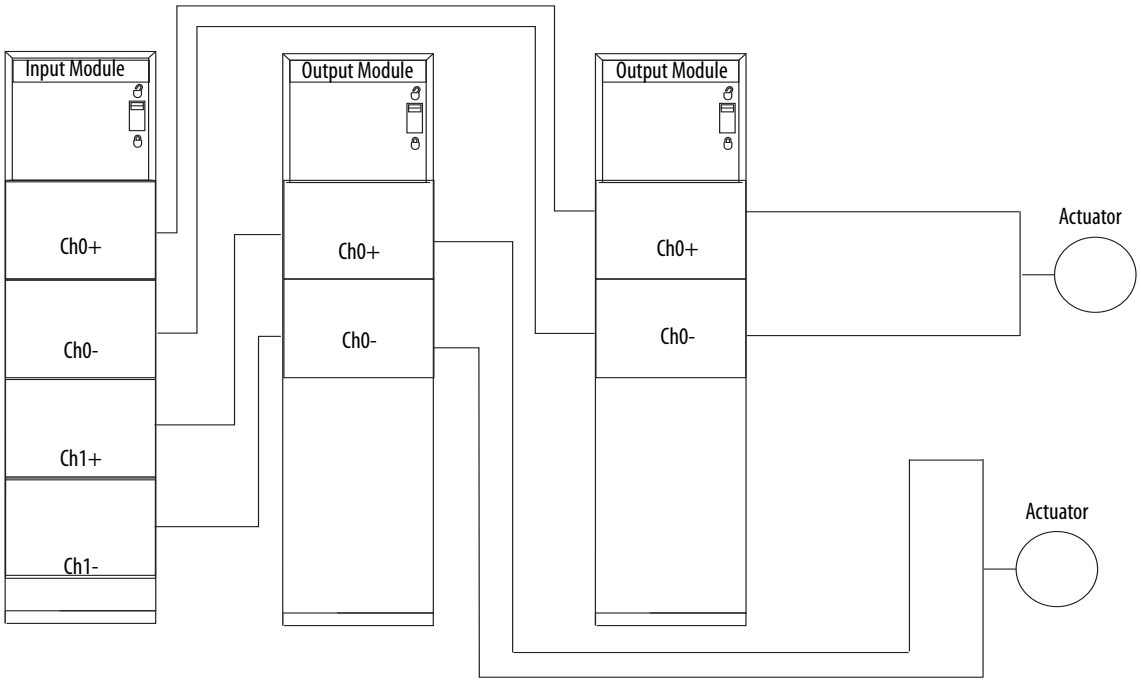
IMPORTANT HART protocol must not be used for safety-related data.

Wiring the HART Analog Output Modules

Make sure you:

- review the considerations in Wiring ControlLogix Analog Output Modules on page 69.
- use the correct documentation (listed in Appendix B) as a reference when wiring the module.

Figure 39 - HART Output Analog Module Wiring



Notes:

FLEX I/O Modules

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Using 1794 Analog Output Modules	84

Overview of FLEX I/O Modules

There are two types of SIL 2-certified FLEX I/O modules:

- Digital I/O modules
- Analog I/O modules

FLEX I/O modules are designed with inherent features that assist them in complying with the requirements of the 61508 Standard. For example, the modules all have a common backplane interface, execute power-up and runtime diagnostics, and offer electronic keying.

Using 1794 Digital Input Modules

To achieve SIL 2, two digital input modules must be used, with field sensors wired to channels on each module. The two channels must be compared by software before reconciling the data.

Requirements When Using FLEX I/O Digital Input Modules

Regardless of the type of FLEX I/O input module used, there are a number of general application considerations that users must follow when applying these modules in a SIL 2 application:

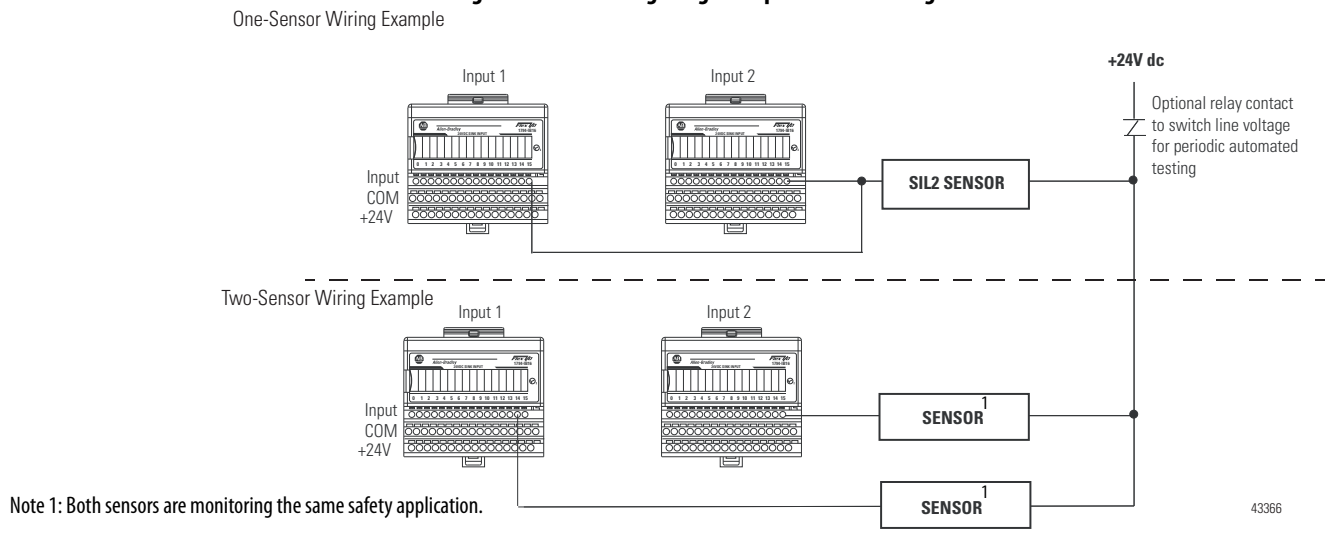
- **Proof tests -** Periodically a system validation test must be performed. Manually, or automatically, test inputs to make sure that all inputs are operational and not stuck in the ON or OFF state. Inputs must be cycled from ON to OFF or OFF to ON.
- Wire sensors to separate input points on two separate modules that are on different network nodes.
- Configuration parameters (for example, RPI, filter values) must be identical between the two modules.

- The same controller must own both modules.
- Monitor the network status bits for the associated module and ensure that appropriate action is invoked via the application logic by these status bits.

Wiring FLEX I/O Digital Input Modules

The wiring diagrams in Figure 40 show two methods of wiring the digital input module. In either case, you must determine whether the use of 1 or 2 sensors is appropriate to fulfill SIL 2 requirements.

Figure 40 - ControlLogix Digital Input Module Wiring

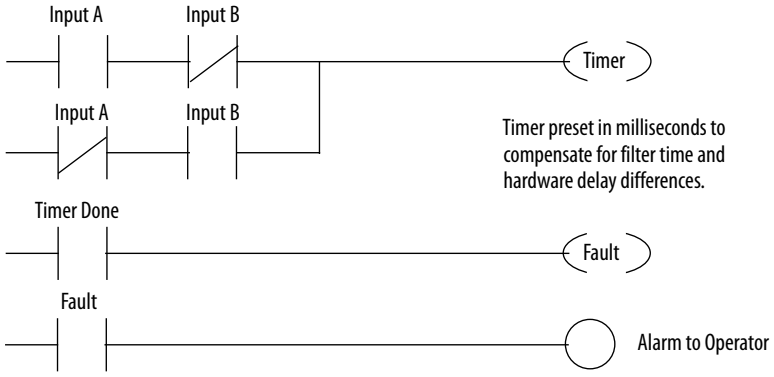


Application logic can compare input values or states for concurrence.

Figure 41 - Compare Input Values

The user program must also contain rungs to annunciate a fault in the event of a sustained miscompare between two points.

Figure 42 - Annunciate a Fault



The control, diagnostics and alarming functions must be performed in sequence.

Using 1794 Digital Output Module

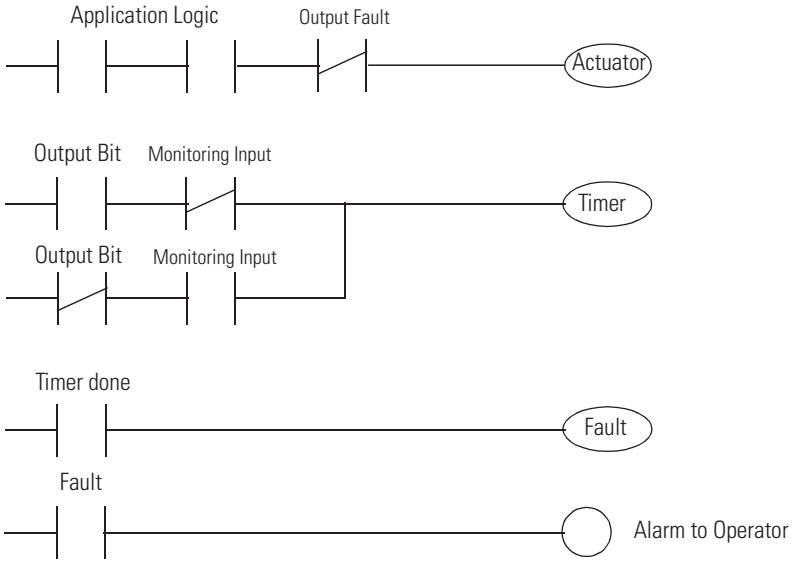
To achieve SIL 2, the output module must be wired back to an input module for monitoring.

Requirements When Using FLEX I/O Digital Output Modules

Regardless of the type of FLEX I/O output module used, there are a number of general application considerations that you must follow when applying these modules in a SIL 2 application:

- **Proof tests-** Periodically a System Validation test must be performed. Manually, or automatically, test outputs to make sure that all outputs are operational and not stuck in the ON or OFF state. Outputs must be cycled from ON to OFF or OFF to ON.

Figure 43 - Testing Outputs



The control, diagnostics and alarming functions must be performed in sequence.

- **Use external relays to disconnect actuator power if output de-energization is critical**. To make sure outputs will de-energize, you must wire an external method that can remove power from the actuator if a short or other fault is detected.

- **Test outputs at specific times to make sure they are operating properly**. The method and frequency of testing is determined by the type of module.

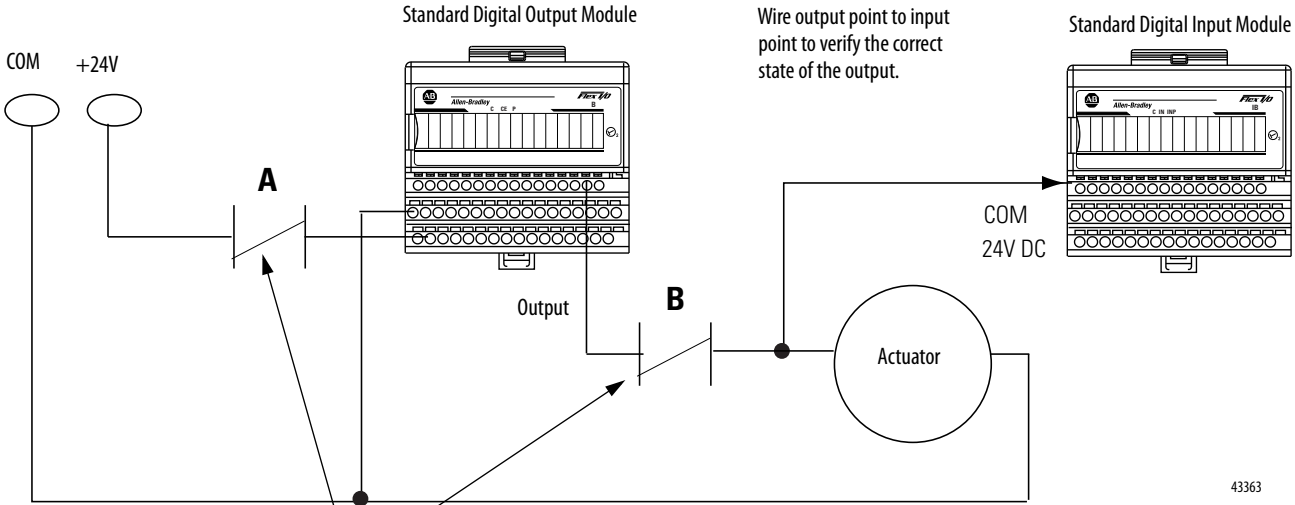
- Wire sensors to separate input points on two separate modules that are on different network nodes.

- Monitor the network status bits for the associated module and make sure that appropriate action is invoked via the application logic by these status bits.

Wiring FLEX I/O Digital Output Modules

When using standard output modules, you must wire an output to an actuator and then back to an input to monitor the output's performance.

Figure 44 - FLEX I/O Standard Output Module Wiring



IMPORTANT: Other configurations are possible as long they are SIL 2 approved.

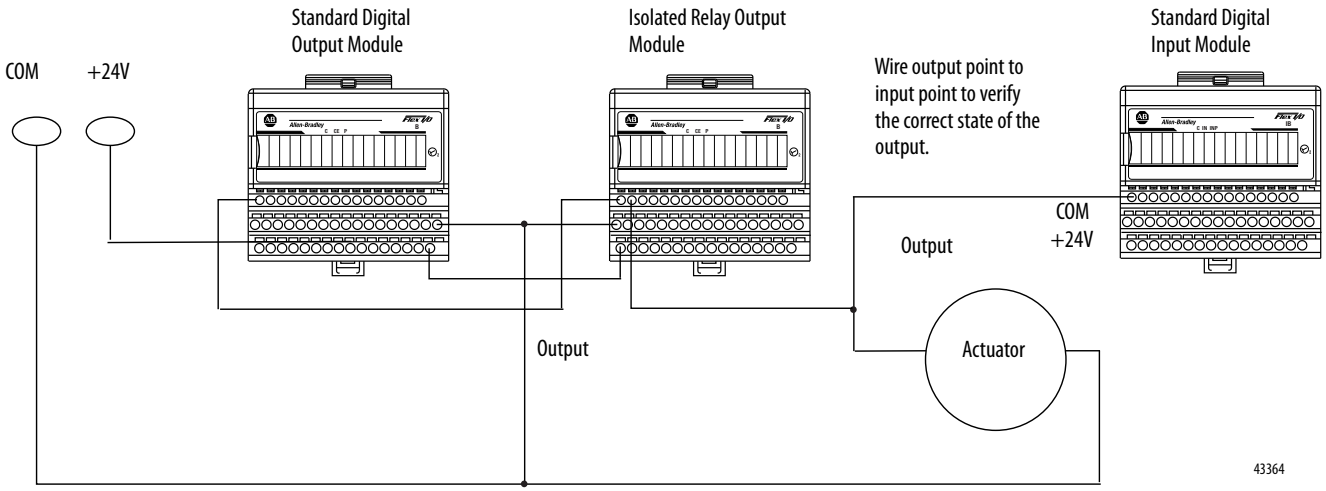
Install a relay in position A or B. This relay is controlled by another output in the ControlLogix/FLEX I/O system. If a short circuit or fault occurs on output modules, the relay can disconnect power to the modules. An isolated relay output module (1794-OW8) can be used for this purpose when it is connected to a different 1794-ACN15 or 1794-ACNR15 ControlNet Adapter module.

Write application logic so that it generates a fault in the event of a miscompare between the requested state of an output (echo) and the actual output state monitored by an input channel (see Figure 43 on page 75).

The control, diagnostics and alarming functions must be performed in sequence.

You can also wire a standard digital output module in series with an isolated relay output module in series with a critical actuator. In the event that a failure is detected, the output from both output modules must be set to OFF to guarantee the Output Loads de-energize. This is shown in Figure 45 on page 77.

Figure 45 - ControlLogix/FLEX I/O Standard Output Module Wiring with an Isolated Relay Module



Note 1: An external relay can be replaced with an isolated relay module that is mounted in another FLEX I/O rail.

Using 1794 Analog Input Modules

To achieve SIL 2, two analog input modules are required. Field sensors must be wired to channels on each module and compared within a deadband. Whether one or two field sensors are required is dependent on the Probability of Failure on Demand (PFD) value of the sensor.

Requirements When Using FLEX I/O Analog Input Modules

You must follow these general application considerations when applying these modules in a SIL 2 application:

- **Proof tests.** Periodically a System Validation test must be performed. Manually, or automatically, test inputs to make sure that all inputs are operational. Field signal levels should be varied over the full operating range to make sure that the corresponding channel data varies accordingly.

- **Calibrate inputs periodically, as necessary**. FLEX I/O modules ship from the factory with a highly accurate level of calibration. However, because each application is different, you are responsible for making sure their FLEX I/O modules are properly calibrated for their specific application.

  You can employ tests in application program logic to determine when a module requires recalibration. For example, to determine whether an input module needs to be recalibrated, a user can determine a tolerance band of accuracy for a specific application. You can then measure input values on multiple channels and compare those values to acceptable values within the tolerance band. Based on the differences in the comparison, you could then determine whether recalibration is necessary.

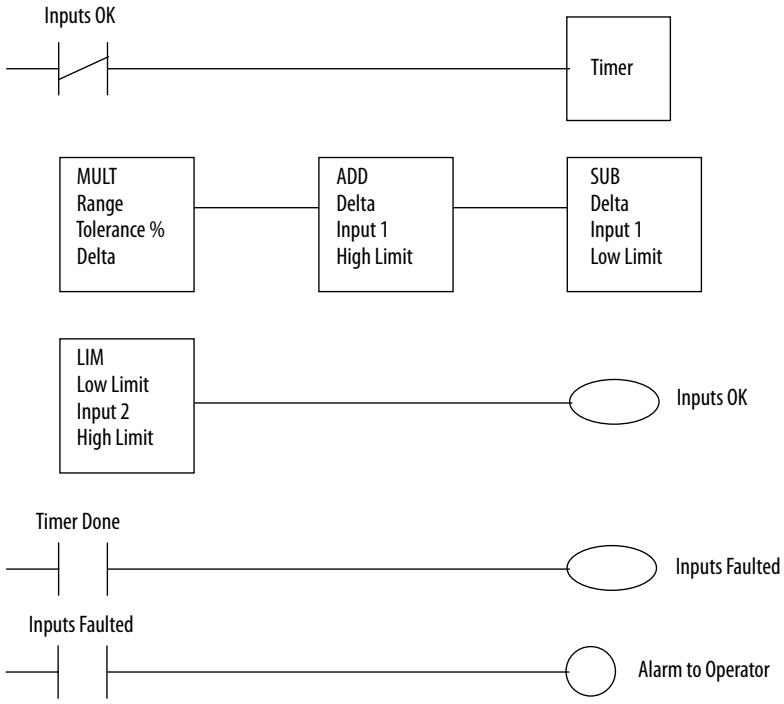
  Calibration (and subsequent recalibration) is **not a safety issue**. However, we recommend that each analog input be calibrated at least every 3 years to verify the accuracy of the input signal and avoid nuisance application shutdowns.

- **Compare analog input data and annunciate miscompares**. When wiring sensors to two inputs channels, the values from those channels must be compared to each other for concurrence within an acceptable range for the application before actuating an output. Any miscompare between the two inputs outside the programmed acceptable range must be annunciated as a fault.

  In Figure 46 on page 79, a user-defined percentage of acceptable deviation (that is, tolerance) is applied to the configured input range of the analog inputs (that is, range) and the result is stored (that is, delta). This delta value is then added to and subtracted from one of the input channels; the results define an acceptable High and Low limit of deviation. The second input channel is then compared to these limits to determine if the input are working properly.

  The input's OK bit preconditions a Timer run that is preset to accommodate an acceptable fault response time and any communication filtering lags in the system. If the inputs miscompare for longer than the preset value, a fault is registered with a corresponding alarm.

Figure 46 - Logic for Comparing Analog Input Data



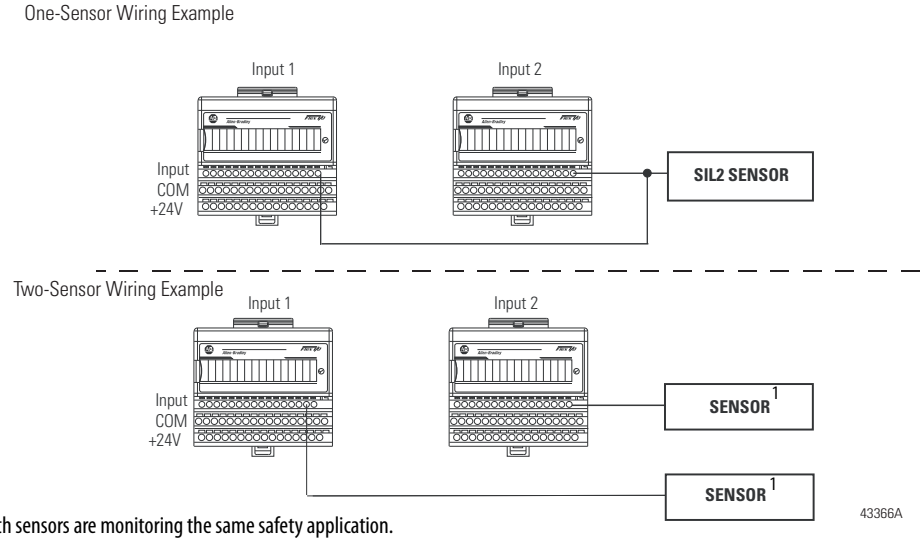
The control, diagnostics and alarming functions must be performed in sequence.

- Configuration parameters (for example, RPI, filter values) must be identical between the two modules.
- The same controller must own both modules.
- Wire sensors to separate input points on two separate modules that are on different network nodes.
- Monitor the network status bits for the associated module and make sure that appropriate action is invoked via the application logic by these status bits.
- Wire sensors to separate input channels on two separate modules that are on different network nodes.

Wiring FLEX I/O Analog Input Modules

The wiring diagrams in this section show two methods of wiring the analog input module. In either case, you must determine whether the use of 1 or 2 sensors is appropriate to fulfill SIL 2 requirements.

Figure 47 - FLEX I/O Analog Input Module Wiring

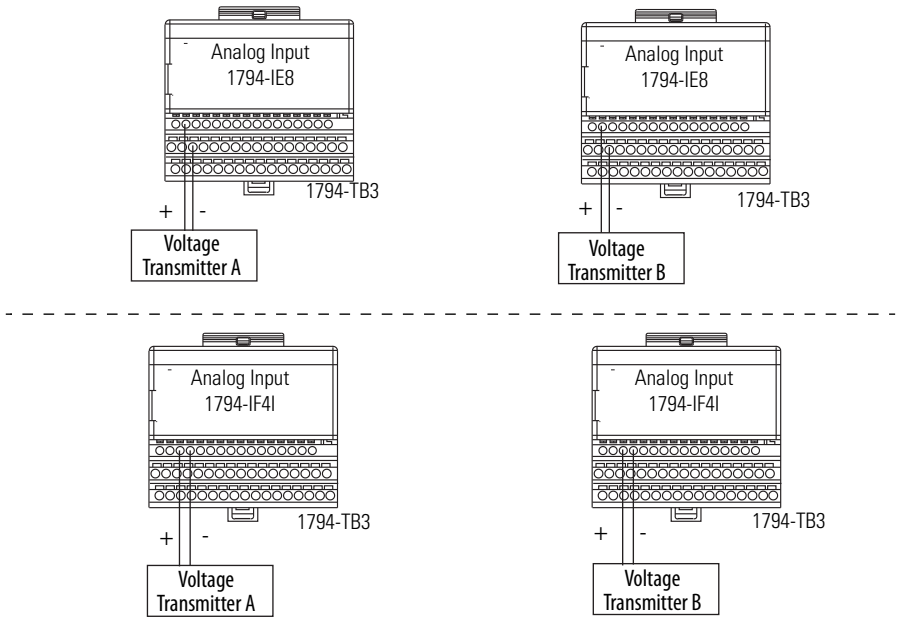


Note 1: Both sensors are monitoring the same safety application.

Wiring the Single-ended Input Module in Voltage Mode

In addition to following the Requirements When Using FLEX I/O Analog Input Modules on page 77, make sure you use the correct documentation to wire the module.

Figure 48 - FLEX I/O Analog Input Module Wiring in Voltage Mode

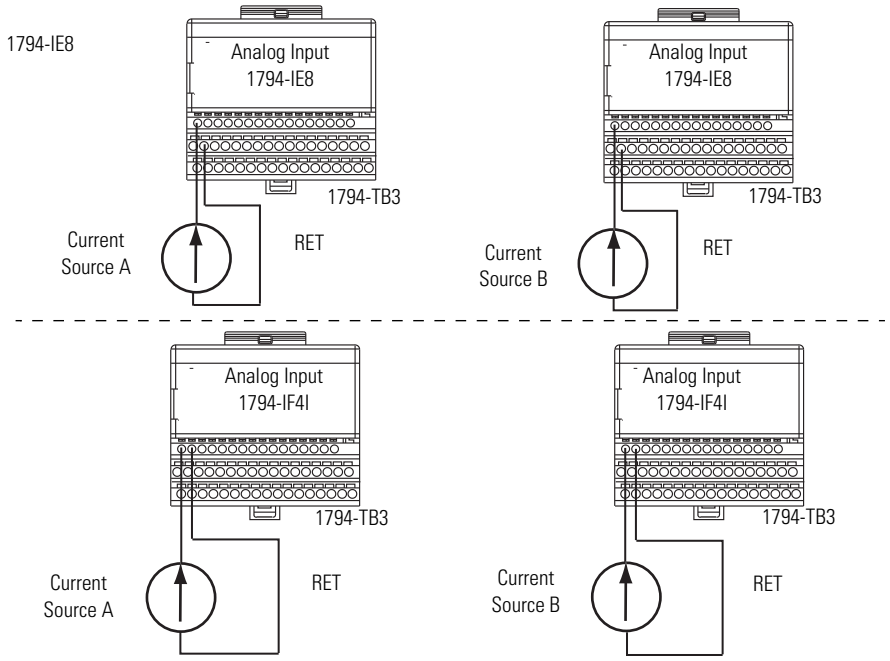


Wiring the Single-ended Input Module in Current Mode

In addition to following the Requirements When Using FLEX I/O Analog Input Modules on page 77, before wiring the module, consider the following application guideline:

- **Place other devices in current loop**. You can locate other devices in an input channel's current loop anywhere as long as the current source can provide sufficient voltage to accommodate all of the voltage drops (each module input is 250 ohms)

Figure 49 - FLEX I/O Analog Input Wiring in Current Mode

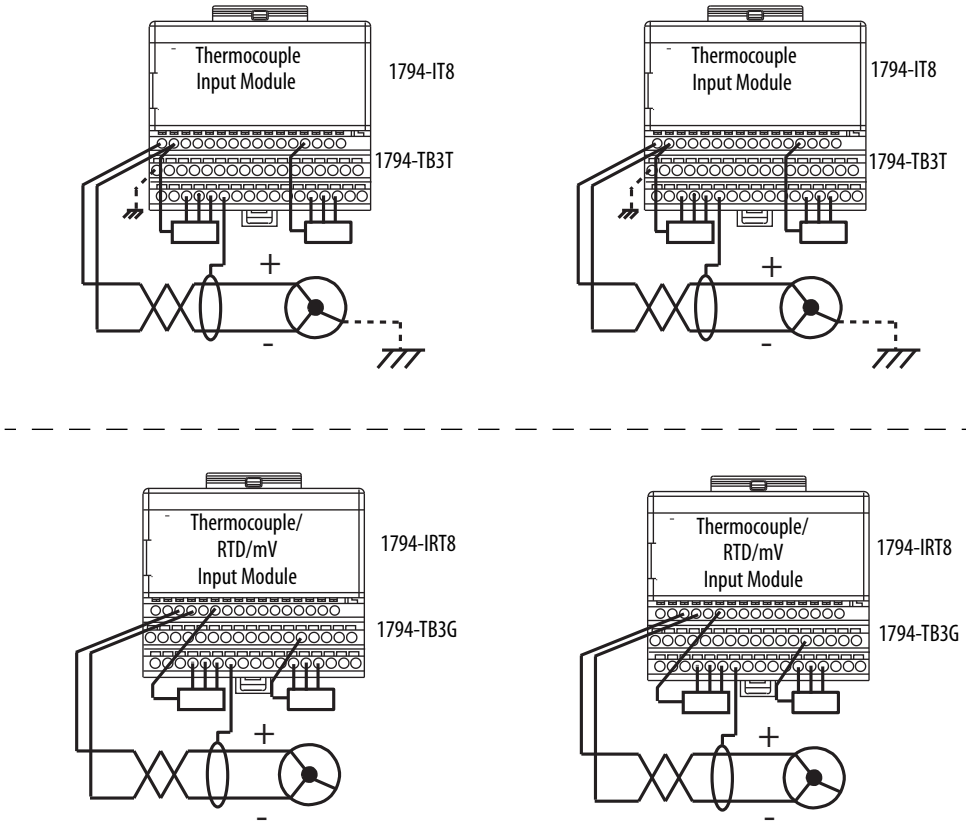


Wiring the Thermocouple Input Module

In addition to following the Requirements When Using FLEX I/O Analog Input Modules on page 77 and before wiring the module, consider the following application guideline:

- **Wire to the same input channel on both modules**. When wiring thermocouples, wire two in parallel to two modules. Use the same channel on each module to make sure of consistent temperature readings.

Figure 50 - FLEX I/O Analog Thermocouple Module Wiring

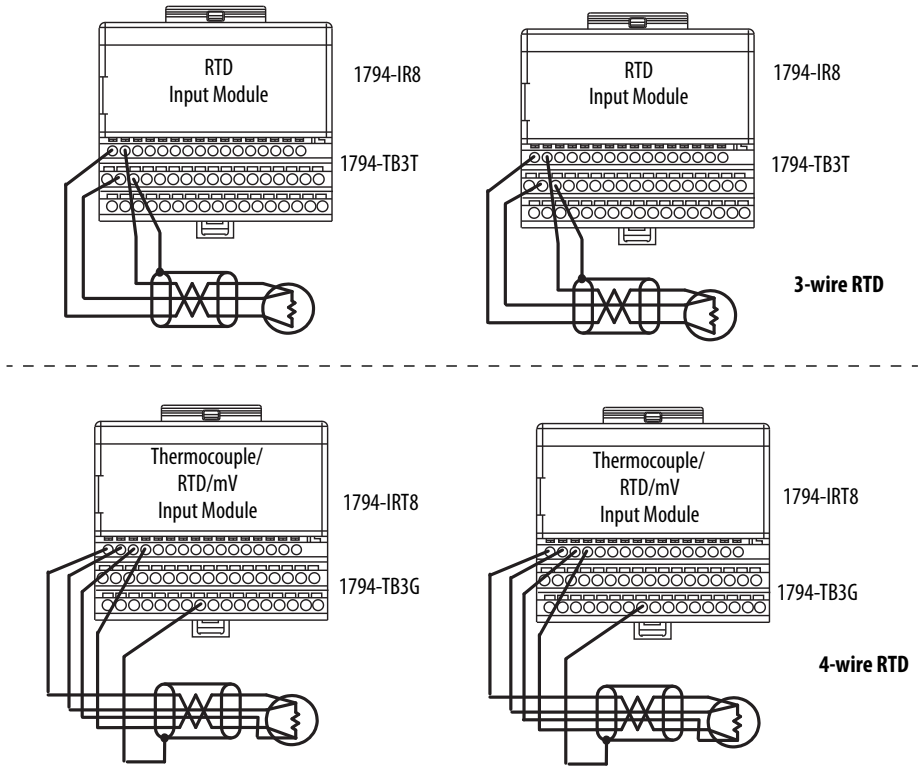


Wiring the RTD Input Module

In addition to following the Requirements When Using FLEX I/O Analog Input Modules on page 77 and before wiring the module, consider the following application guideline:

- RTDs cannot be wired in parallel without severely affecting their accuracy. Two sensors must be used.

Figure 51 - FLEX I/O Analog RTD Module Wiring



Two-, three-, or four-wire RTDs can be used as applicable to the associated RTD input module.

Using 1794 Analog Output Modules

A single analog output module, along with an analog input module for monitoring is required to achieve SIL 2.

IMPORTANT	We strongly recommended that you do not use analog outputs to execute the safety function that results in a safe state. Analog output modules are slow to respond to an ESD command and are therefore not recommended for use ESD output modules. The use of digital output modules and actuators to achieve the ESD de-energized state is recommended.

Requirements When Using FLEX I/O Analog Output Modules

Follow these general application considerations when applying the analog output modules in a SIL 2 application:

- **Proof tests -** Periodically a System Validation test must be performed. Manually, or automatically, test outputs to make sure that all outputs are operational. Channel data should be varied over the full operating range to make sure that the corresponding field signal levels vary accordingly.

- **Calibrate outputs periodically, as necessary**. FLEX I/O modules ship from the factory with a highly accurate level of calibration. However, because each application is different, you are responsible for making sure their FLEX I/O modules are properly calibrated for their specific application.

  You can employ tests in application program logic to determine when a module requires recalibration. For example, to determine whether an output module needs to be recalibrated, a user can determine a tolerance band of accuracy for a specific application. You can then measure output values on multiple channels and compare those values to acceptable values within the tolerance band. Based on the differences in the comparison, you could then determine whether recalibration is necessary.

  Calibration (and subsequent recalibration) is **not a safety issue**. However, we recommend that each analog output be calibrated at least every 3 years to verify the accuracy of the input signal and avoid nuisance application shutdowns.

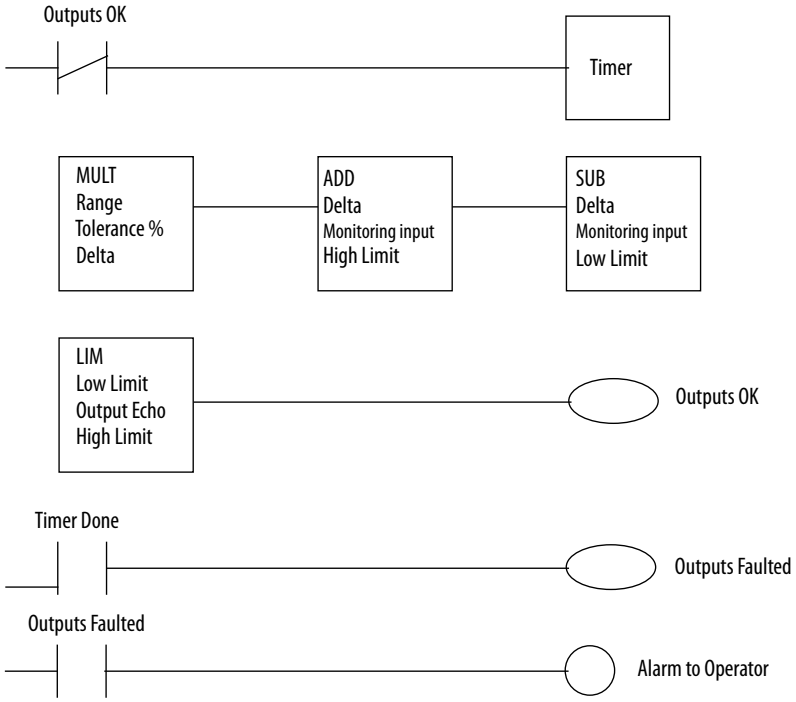
- **For typical emergency shutdown (ESD) applications, outputs must be configured to de-energize**. When configuring any FLEX I/O output module, each output must be configured to de-energize in the event of a fault and in the event of the controller going into Program mode.

- **Wire outputs back to inputs and examine output data feedback signal.** You must wire an analog output to an actuator and then back to an analog input to monitor the output's performance. (The use of feedback transmitters to verify an output's performance is acceptable.) The application logic must examine the Data Feedback value associated with each output point to make sure that the requested output command from the controller was received by the module. The value must be compared to the analog input that is monitoring the output to make sure the value is in an acceptable range for the application.

  In the ladder diagram in Figure 52, a user-defined percentage of acceptable deviation (that is, tolerance) is applied to the configured range of the analog input and output (that is, range) and the result is stored (that is, delta). This delta value is then added to and subtracted from the monitoring analog input channel; the results define an acceptable High and Low limit of deviation. The analog Output Feedback is then compared to these limits to determine if the output are working properly.

The output's OK bit preconditions a Timer run that is preset to accommodate an acceptable fault response time and any communication filtering, or output, lags in the system. If the monitoring input value and the Output Feedback miscompare for longer than the preset value, a fault is registered with a corresponding alarm.

Figure 52 - Monitoring an Analog Output with an Analog Input



The control, diagnostics and alarming functions must be performed in sequence.

- When wiring two analog output modules in the same application, make sure:
  - Both modules use identical configuration.
  - The same controller owns both modules.
- The two analog output modules must be on separate FLEX I/O rails. They must not share the same FLEX adapter.
- Monitor the network status bits for the associated module and make sure that appropriate action is invoked via the application logic by these status bits.

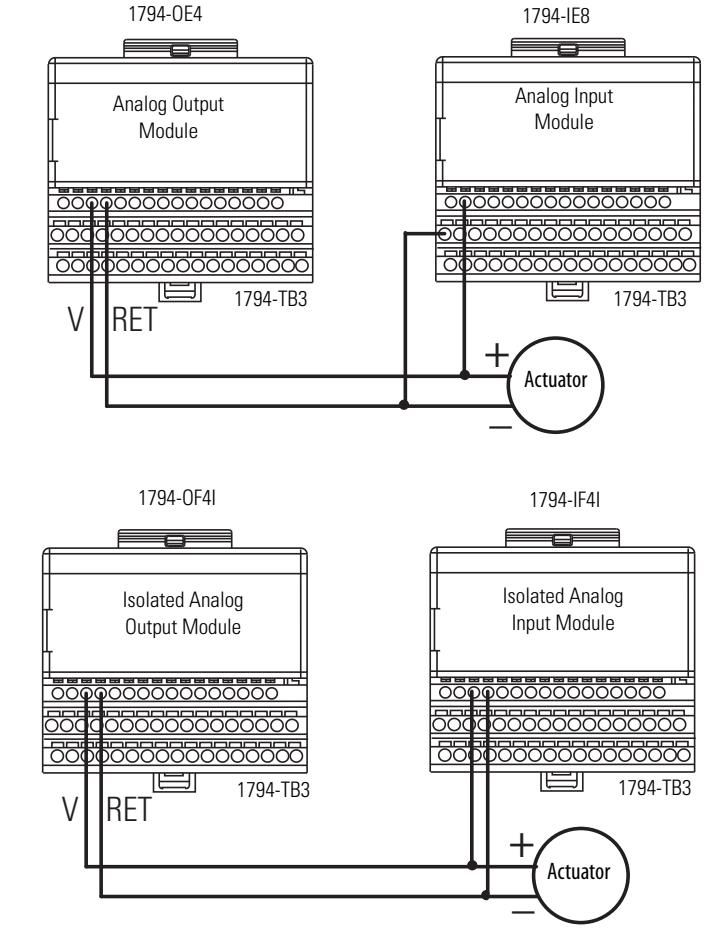
Wiring FLEX I/O Analog Output Modules

In general, good design practice dictates that each analog output must be wired to a separate input terminal to make sure that the output is functioning properly.

Wiring the Analog Output Module in Voltage Mode

You must wire analog outputs to an actuator and then back to an analog input to monitor the output performance.

Figure 53 - Analog Input Module Wiring Example

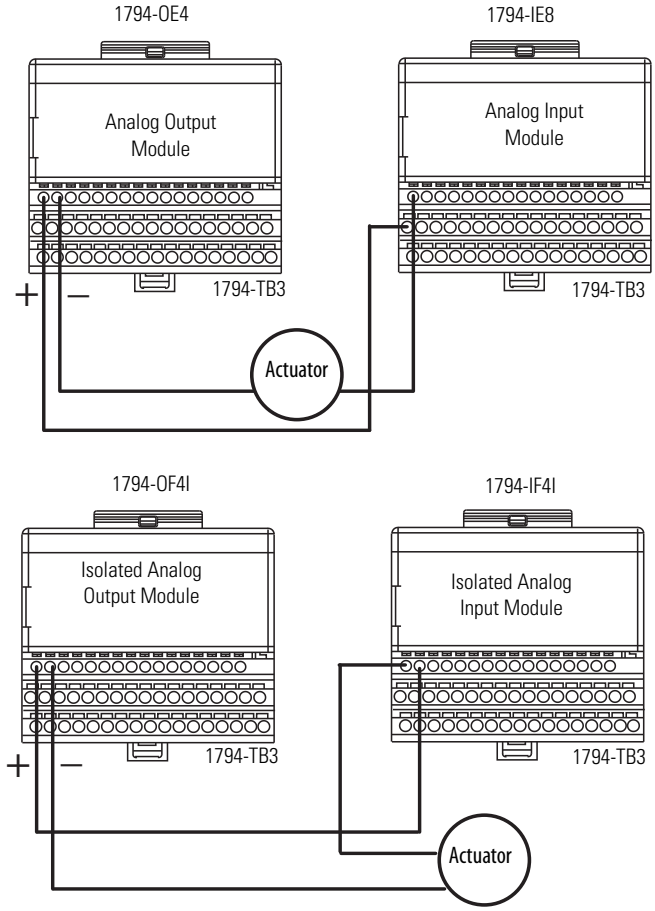


Wiring the Analog Output Module in Current Mode

In addition to following the Requirements When Using FLEX I/O Analog Output Modules on page 84, consider the following application guideline before wiring the module in Current mode:

- **Place other devices in current loop**. You can locate other devices in an output channel's current loop anywhere as long as the current source can provide sufficient voltage to accommodate all of the voltage drops.

Figure 54 - Analog Output Wiring Example



Requirements for Application Development

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Software for SIL 2-Related Systems

The application software for the SIL 2-related automation system is created using the programming tool, that is, RSLogix 5000 software, according to IEC 61131 3.

The application program has to be created by using the programming tool and contains the specific equipment functions that are to be carried out by the ControlLogix system. Parameters for the operating function are also entered into the system using the programming software.

SIL 2 Programming

The safety concept of the SIL 2 ControlLogix system assumes the following:

- The programming software is installed correctly.
- Control system hardware is installed in accordance with product installation guidelines.
- User application code (user program) uses common and good design practices.
- A test plan is documented and adhered to, including well-understood proof test requirements and procedures.
- A well-designed validation process is defined and implemented.

For the initial start-up of a safety-related ControlLogix system, the entire system must be checked by a complete functional test. After a modification of the application program, the modified program or logic must be checked.

For more information on how users should handle changes to their application program, see Changing Your Application Program on page 97.

Programming Languages

It is good engineering practice to keep safety-related logic as simple and easy to understand as possible. The preferred language for safety-related functions is ladder logic, followed by function block. Structured text and sequential function chart are not recommended for safety-related functions.

Programming Options

Pre-programmed SIL 2 I/O Add-On Instructions can be used in RSLogix 5000 software, version 20 or later. If you choose to use Add-On Instructions, refer to ControlLogix SIL 2 System Configuration Using SIL 2 Add-On Instructions, publication 1756-AT012.

Using the SIL 2 Add-On Instructions greatly simplifies the programming required for a SIL 2 system. However, these instructions may not be suitable for use in all SIL 2 applications and system configurations. You need to evaluate the suitability of a SIL 2 Add-On Instruction that is used in a safety-related function.

All Add-On Instructions require the use of hardware termination boards.

Security

The user must define what measures are to be applied for the protection against manipulation.

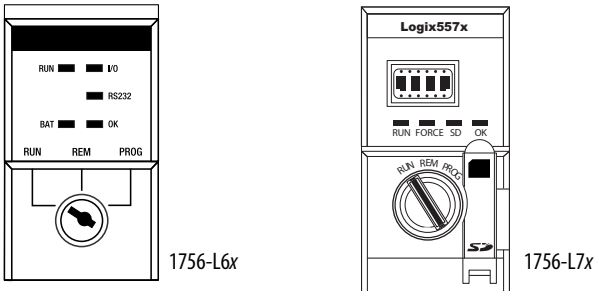
In the ControlLogix system and in the programming software, protection mechanisms are available that help prevent unintentional or unauthorized modifications to the safety system:

- The following tools may be employed for security reasons in a SIL 2-certified ControlLogix application:
  - Logix CPU Security
  - Routine Source Protection
  - FactoryTalk® AssetCentre

  Each of these features or products offers different security features, including password protection, at varying levels of granularity throughout the application. The description of these tools is too large in scope to list in detail here. Contact your local Rockwell Automation representative for more information.

- The controller keyswitch must be in the RUN position and the key removed during normal operating conditions.

Figure 55 - Keyswitch in Run Mode



- In RSLogix 5000 software, version 18 and later, you can set tags to be standard, read-only, or constant values. Read-only blocks external devices (for example, HMIs and other controllers) from changing a tag. Constants block everything, including user logic from changing a tag value. All SIL 2 safety-related tags should be set to read-only. Where possible, configure SIL 2 safety tags as constant value tags.

The requirements of the safety and application standards regarding the protection against manipulations must be observed. The authorization of employees and the necessary protection measures are the responsibility of the individuals starting and maintaining the SIL 2 safety system.

Basics of Application Program Development and Testing

The application program is intended to be developed by the system integrator and/or user. The developer must consider general procedures for programming ControlLogix SIL 2 applications listed below (this does not require independent third party review).

- Specification of the SIL 2 safety control function, including the following:
  - Specifications
  - Flow and timing charts
  - Engineering diagrams
  - Sequence charts
  - Program description
  - Program review process
- Writing the application program
- Checking by independent reviewer
- Verification and validation

All application logic must be independently reviewed and tested. To facilitate reviews and reduce unintended responses, developers should limit the set of instructions to basic Boolean/ladder logic (such as examine On/Off, Timers, Counters, and so on) whenever possible. This set should include instructions that can be used to accommodate analog variables, such as the following:

- Limit tests
- Comparisons
- Math instructions

For more information, see Proof Tests on page 28.

Functional Specification Guidelines

You must create a specification for your control function. Use this specification to verify that program logic correctly and fully addresses your application's functional and safety control requirements. The specification may be presented in a variety of formats, depending on your application.

The specification must include a detailed description that includes the following (if applicable):

- Sequence of operations
- Flow and timing diagrams
- Sequence charts
- Program description
- Program print out
- Written descriptions of the steps with step conditions and actuators to be controlled, including the following:
  - Input definitions
  - Output definitions
  - I/O wiring diagrams and references
  - Theory of operation
- Matrix- or table form of stepped conditions and the actuators to be controlled, including the sequence and timing diagrams
- Definition of marginal conditions, for example, operating modes, EMERGENCY STOP, and others

The I/O-portion of the specification must contain the analysis of field circuits, that is, the type of sensors and actuators.

Sensors (digital or analog)

- Signal in standard operation (dormant current principle for digital sensors, sensors OFF means no signal)
- Determination of redundancies required for SIL levels
- Discrepancy monitoring and visualization, including the user's diagnostic logic

Actuators

- Position and activation in standard operation (normally OFF)
- Safe reaction or positioning when switching OFF
- Discrepancy monitoring and visualization, including the user's diagnostic logic

Creating the Application Program

Consider the following when developing the application program logic.

Logic and Instructions

The logic and instructions used in programming the application must be:

- easy to understand.
- easy to trace.
- easy to change.
- easy to test.
- well-documented.

Program Language

You must implement simple, easy to understand:

- ladder.
- other IEC 61131-3-compliant language.
- function blocks with specified characteristics.

We use ladder, for example, because it is easier to visualize and make partial program changes with this format.

Program Identification

The application program is clearly identified by one of the following:

- Name
- Date
- Revision
- Any other user identification information

SIL Task/Program Instructions

The user application should contain a single SIL task composed of programs and routines. The SIL 2 task must be the controller's top priority task and the user-defined watchdog must be set to accommodate the SIL 2 task.

IMPORTANT	Motion-related functions are not allowed and must not be used.

IMPORTANT	You must dedicate a specific task for safety-related functions and set that task to the highest priority (1). SIL 2 safety logic and logic intended for use in non-SIL 2 functions must be separate, or everything in the task containing safety must be treated as safety-related.

Forcing

The following rules apply to forcing in a project:

- You must remove forces on all SIL 2 tags and disable forcing before beginning normal operation for the project.
- You must not force SIL 2 tags after validation is performed and during controller operation in Run mode.

IMPORTANT	Forcing must not be used during normal operation, as well as during final system test and validation.

Checking the Application Program

To check safety-related application logic for adherence to specific safety functions, you must generate a suitable set of test cases that cover the safety specification. The set of test cases needs to be well-written and filed as the test specification.

Suitable tests must also be generated for the numeric evaluation of formulas. Equivalent range tests are acceptable. These are tests within defined value ranges, at the limits, and outside the defined value ranges. The test cases must be selected to prove the correctness of the calculation. The necessary number of test cases depends on the formula used and must comprise critical value pairs.

However, active simulation with sources cannot be omitted as this is the only means of detecting correct wiring of the sensors and actuators to the system. Furthermore, this is the only means of testing the system configuration. Users should verify the correct programmed functions by forcing I/O or by manual manipulation of sensors and actuators.

Verify Download and Operation

Verify the download of the application program and its proper operation. A typical technique is to upload the completed program file and perform a compare of that file against what is stored in the programming terminal.

IMPORTANT Do not use memory cards to automatically transfer the safety application. After a safety application is downloaded, you must verify the download.

The AutoFlash firmware feature is not supported for SIL-2 safety applications and must not be used.

IMPORTANT If the controller has a USB port, it is intended for temporary local programming purposes only and not intended for permanent connection.

These are typical steps for performing a verification in RSLogix 5000 software.

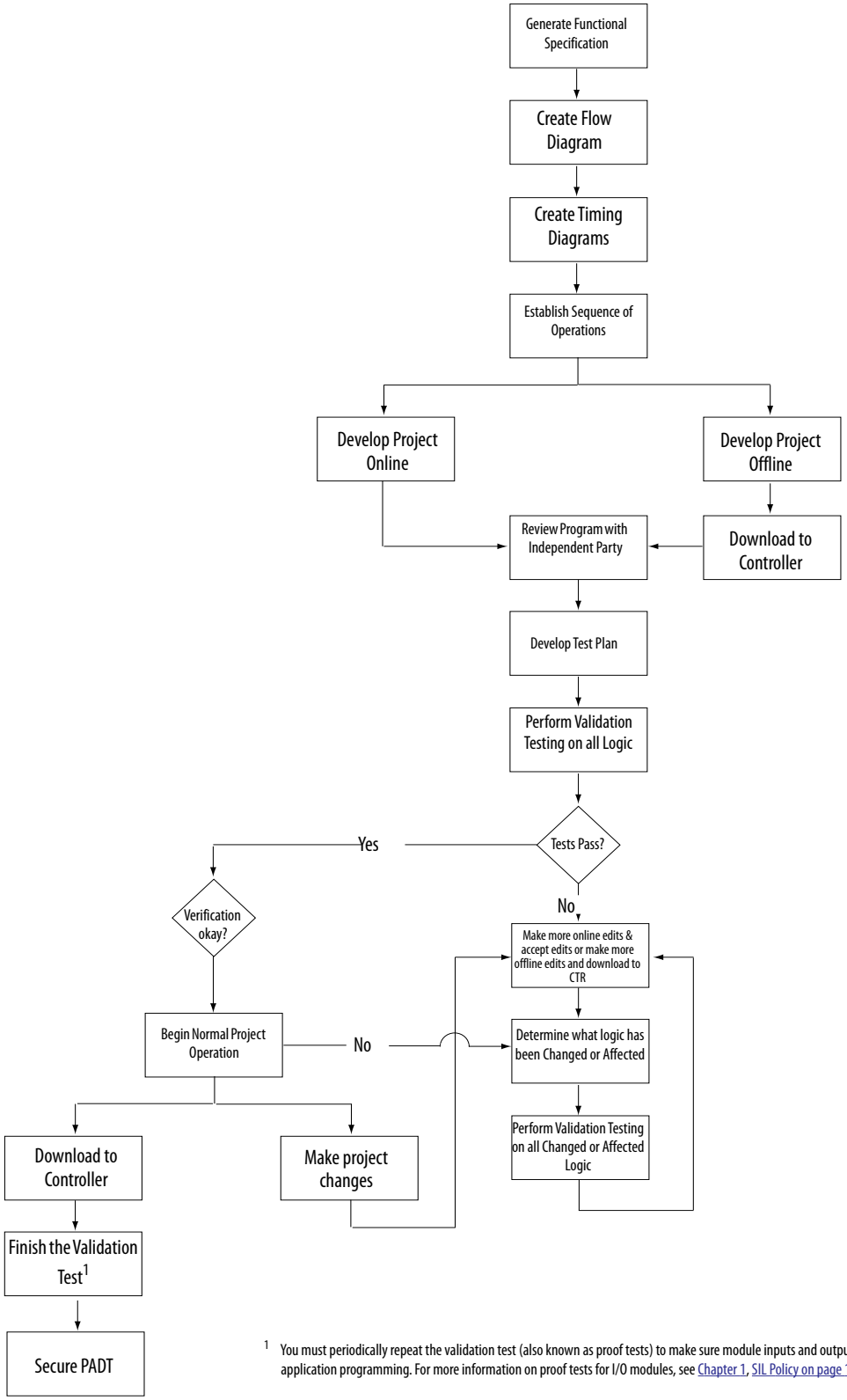
1. With the programming software not running, rename the offline project.
2. Start the programming software, upload the controller project, and save it.
3. Open the compare tool and select both files.
4. Start the compare operation.
5. Review the compare output results and verify that everything matches without error.

   Project documentation differences will likely exist.
6. Save the compare results as part of the verification process.
7. Delete the upload file.
8. Rename the original project file (change back) to the original project name to maintain project documentation.

Commissioning Life Cycle

Figure 56 shows the steps required during application program development, debugging and commissioning.

Figure 56 - Application Development Life Cycle


Generate Functional Specification
Create Flow Diagram
Create Timing Diagrams
Establish Sequence of Operations
Develop Project Online
Develop Project Offline
Review Program with Independent Party
Download to Controller
Develop Test Plan
Perform Validation Testing on all Logic
Tests Pass?
Yes
No
Verification okay?
Make more online edits & accept edits or make more offline edits and download to CTR
Begin Normal Project Operation
No
Determine what logic has been Changed or Affected
Perform Validation Testing on all Changed or Affected Logic
Download to Controller
Make project changes
Finish the Validation Test[1]
Secure PADT

[1] You must periodically repeat the validation test (also known as proof tests) to make sure module inputs and outputs are functioning properly and as commanded by the application programming. For more information on proof tests for I/O modules, see Chapter 1, SIL Policy on page 13.

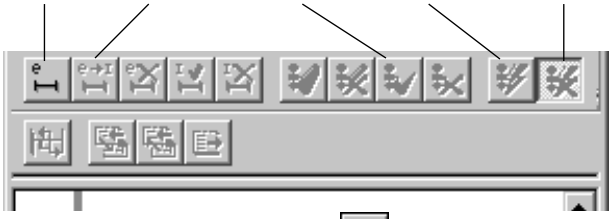
Changing Your Application Program

The following rules apply to changing your application program in RSLogix 5000 software:

IMPORTANT You cannot make program edits while the program is online if the changes prevent the system from executing the safety function or if alternative protection methods are not in place.

- Program edits are not recommended and should be limited. For example, minor changes such as changing a timer preset or analog setpoint are allowed.
- Only authorized, specially-trained personnel can make program edits. These personnel should use all supervisory methods available, for example, using the controller keyswitch and software password protections.
- Anyone making data or programming edits to an operational system assumes the central safety responsibility while the changes are in progress. These personnel must also maintain safe application operation.
- Prior to making any program edits, you must perform an impact analysis by following the safety specification and other lifecycle steps described in Figure 56 on page 96 as if the edits were an entirely new program.
- Users must sufficiently document all program edits, including:
  - authorization.
  - impact analysis.
  - execution.
  - test information.
  - revision information.
- Multiple users cannot edit a program from multiple programming terminals simultaneously.
- Changes to the safety application software–in this case, RSLogix 5000 software– must comply with IEC 61511 standard on process safety section 11.7.1 Operator Interface requirements.
- When the ControlLogix controller keyswitch is in the RUN position (controller is in Run mode), you cannot make online edits.
- You can edit the relay ladder logic portion of the safety program using one of the following methods described in Table 3.

Table 3 - Methods of Changing Your Application Program

Method	Required Steps	Controller Keyswitch Position	Key Points to this Method
Offline	Perform the tasks described in the flow chart in Figure 56 on page 96.	PROG	You must re-validate the entire application before returning to normal operation.
Online	1. Turn the controller key to the REM position. 2. Use the Online Edit Toolbar to start, accept, test and assemble your edits. The toolbar is shown below. Start pending rung edit. Accept pending rung edits. Assemble program edits. Test program edits. Untest program edits.  a. Click the start pending rung edits button . A copy is made of the rung you want to edit. b. Change your application program as needed. At this point, the original program is still active in the controller. Your program changes are made in the copied rungs. Changes do not affect the outputs until you test program edits in step d. c. Click the accept pending rung edits button . Your program changes are verified and downloaded to the controller. The controller now has the changed program and the original program. However, the controller continues to execute the original program. You can see the state of the inputs, and changes do not affect the outputs. d. Click the test program edits button . e. Click Yes to test the edits. Changes are now executed and affect the outputs; the original program is no longer executed. However, if you are not satisfied with the result of testing the edits, you can discard the new program by clicking on the untest program edits button if necessary. If you untest the edits, the controller returns to the original program. f. Click the assemble program edits button . g. Click Yes to assemble the edits. The changes are the only program in the controller, and the original program is discarded. 3. Perform a partial proof test of the portion of the application affected by the program edits. 4. Turn the controller key back to the RUN position to return the project to Run mode. We recommend you upload the new program to your programming terminal to help ensure consistency between the application in the controller and on the programming terminal. 5. Remove the key.	REM	The project remains online but operates in the remote Run mode. When edits are completed, you are required to validate only the changed portion of the application program. We recommend that online edits be limited to minor program modifications such as setpoint changes or ladder logic rung additions, deletions and modifications. **IMPORTANT**:This option to change the application program is available for changes to relay ladder logic only. You cannot use this method to change function block programming. For more detailed information on how to edit ladder logic while online, see the Logix5000 Controllers Quick Start, publication 1756-QS001.

IMPORTANT If any changes are needed to the program in the safety loop, they must be done in accordance with IEC 61511-1, paragraph 11.7.1.5, which states:

'The Safety Instrumentation System (SIS) operator interface design shall be such as to prevent changes to SIS application software. Where safety information needs to be transmitted from the basic process control system (BPCS) to the SIS then systems should be used that can selectively allow writing from the BPCS to specific SIS variables. Equipment or procedures should be applied to confirm the proper selection has been transmitted and received by the SIS and does not compromise the safety function of the SIS.'

Faults in the ControlLogix System

Topic	Page
Detecting and Reacting to Faults	99
Module Fault Reporting for Any ControlLogix or FLEX I/O Module	100
Checking Keyswitch Position with GSV Instruction	100
Examining an 1756 Analog Input Module's High Alarm	101
Additional Resources	102

In addition to providing information on module fault reporting, this chapter explains two example conditions that will generate a fault in a SIL 2-certified ControlLogix system:

- Keyswitch changing out of Run mode
- High alarm condition on an analog input module

Detecting and Reacting to Faults

The ControlLogix architecture provides many ways of detecting and reacting to faults in the system.

- Various device objects can be interrogated to determine the current operating status.
- Modules provide run-time status of their operation and of the process that is executing.
- You can configure a ControlLogix system to identify and handle faults, including such tasks as:
  - developing a fault routine.
  - creating a user-defined major fault.
  - monitoring minor faults.
  - developing a power-up routine.

  See the Logix5000 Controllers Common Procedures Programming Manual, publication 1756-PM001, for more information.

It is your responsibility to determine what data is most appropriate for your application to initiate a shutdown sequence.

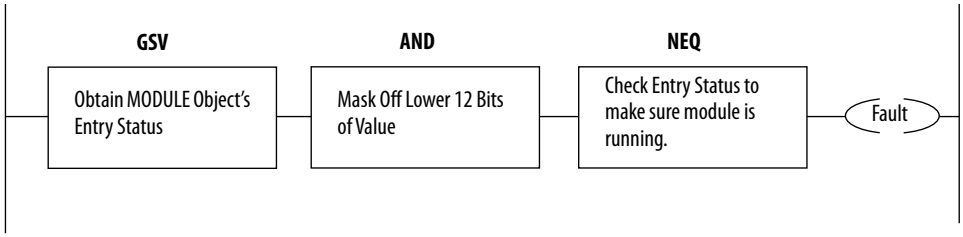
TIP To help handle faults, make sure you have completed the input (see Checklist for SIL Inputs on page 140) and output (see Checklist for SIL Outputs on page 142) checklists for their application.

Module Fault Reporting for Any ControlLogix or FLEX I/O Module

You must verify that all components in the system are operating properly. This can be accomplished in ladder logic through the use of the Get System Value instruction (GSV) and an examination of the MODULE Object's Entry Status' attribute for a running condition.

An example of how this might be done is shown in Figure 57. This method, or something similar, must be used to interrogate the health of each I/O module in the system.

Figure 57 - Example of Checking a Module's Health in Ladder Logic



For more information on the GSV instruction, monitor the SlotStatusBits for the Input tag of the associated adapter. The lower 8 bits of this tag correspond to the associated slot. For example, the tag "Node3:I.Slot1StatusBits" is defined as follows:

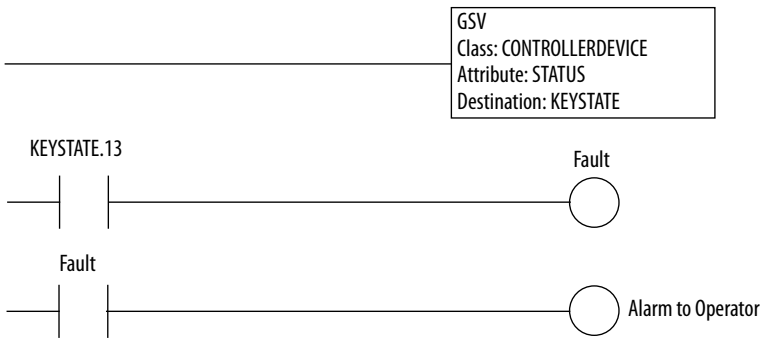
- Node 3 is the name given to the adapter, in this example, a 1794-ACNR15.
- I indicates the Input file.
- SlotStatusBits is a 32-bit value, where the lower 8 bits correspond to a FLEX I/O module, as shown.

Module 7	Module 6	Module 5	Module 4	Module 3	Module 2	Module 1	Module 0

Checking Keyswitch Position with GSV Instruction

The following rungs generate a fault if the keyswitch on the front of the controller is switched from the RUN position.

Figure 58 - Keyswitch State (Operation mode) Change Logic



In Figure 58 on page 100, the Get System Value (GSV) instruction interrogates the STATUS attribute of the CONTROLLERDEVICE object and stores the result in a word called KEYSTATE, where bits 12 and 13 define the state of the keyswitch as shown in Table 4.

Table 4 - Keyswitch State Bits

Bit 13	Bit 12	Description
0	1	Keyswitch in Run position
1	0	Keyswitch in Program position
1	1	Keyswitch in Remote position

If bit 13 is ever ON, then the keyswitch is not in the RUN position. Examining bit 13 of KEYSTATE for an ON state will generate a fault.

It is your responsibility to determine appropriate behavior when a fault is present.

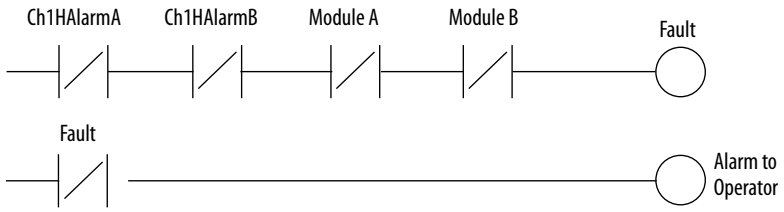
For more information on the accessing the CONTROLLERDEVICE object, see the Logix5000 Controllers General Instructions Reference Manual, publication 1756-RM003.

Examining an 1756 Analog Input Module's High Alarm

ControlLogix analog modules perform processing and comparison of field data values right on the module, allowing for easy examination of status bits to initiate a fault.

For example, the 1756-IF8 module can be configured with user-defined alarm values that, when exceeded, will set a status bit on the module, which is then sent back to the controller. You can examine the state of these bits to initiate a fault as shown in Figure 59.

Figure 59 - High Alarm Bit to Trigger Fault



In the example above, the High Alarm bits for channels 1 and 2 are being examined for a condition to initiate a fault. During operation, as the analog input module processes analog signals from the field sensors, if the value exceeds the user-defined value for High Alarm, the alarm bit is set and a fault is declared.

It is your responsibility to determine appropriate behavior when a fault is present.

Additional Resources

The ControlLogix architecture provides the user many ways of detecting and reacting to faults in the system. Various device objects can be interrogated to determine the current operating status. Additionally, modules provide run-time status of their operation and of the process.

Resource	Description
Logix5000 Controllers General Instructions Reference Manual, publication 1756-RM003	Provides information on how to use specific instructions to get and set controller system data stored in device objects
Logix5000 Controllers Common Procedures Programming Manual, publication 1756-PM001	Provides information on controller fault codes, including major and minor codes and on creating fault and power-up routines
ControlLogix Analog I/O Modules User Manual, publication 1756-UM009	Provides information on accessing modules' run-time operational and process status
ControlLogix Digital I/O Modules User Manual, publication 1756-UM058	

Use of Human-to-Machine Interfaces

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Precautions

You must exercise precautions and implement specific techniques on HMI devices. These precautions include, but are not restricted to the following:

- Limited access and security
- Specifications, testing and validation
- Restrictions on data and access
- Limits on data and parameters

For more information on how HMI devices fit into a typical SIL loop, see Figure 10 on page 24.

Use sound techniques in the application software within the HMI and controller.

Accessing Safety-related Systems

HMI- related functions consist of two primary activities: reading and writing data.

Reading Parameters in Safety-related Systems

Reading data is unrestricted because reading doesn't affect the operation or behavior of the safety system. However, the number, frequency, and size of the data being read can impact controller performance. To avoid safety-related nuisance trips, use good communication practices to limit the impact of communication processing on the controller. Do not set read rates to the fastest rate possible.

Changing Safety-related Parameters in SIL-rated Systems

A parameter change in a safety-related loop via an external (that is, outside the safety loop) device (for example, an HMI) is allowed only with the following restrictions:

- Only authorized, specially-trained personnel (operators) can change the parameters in safety-related systems via HMIs.
- The operator who makes changes in a safety-related system via an HMI is responsible for the effect of those changes on the safety loop.
- You must clearly document variables that are to be changed.
- You must use a clear, comprehensive, and explicit operator procedure to make safety-related changes via an HMI.
- Changes can only be accepted in a safety-related system if the following sequence of events occurs.

  a. The new variable must be sent twice to two different tags; that is, both values must not be written to with one command.
  b. Safety-related code, executing in the controller, must check both tags for equivalency and make sure they are within range (boundary checks).
  c. Both new variables must be read back and displayed on the HMI device.
  d. Trained operators must visually check that both variables are the same and are the correct value.
  e. Trained operators must manually acknowledge that the values are correct on the HMI screen that sends a command to the safety logic, which allows the new values to be used in the safety function.

  In every case, the operator must confirm the validity of the change before they are accepted and applied in the safety loop.

- Test all changes as part of the safety validation procedure.
- Sufficiently document all safety-related changes made via HMI, including the following:
  - Authorization
  - Impact analysis
  - Execution
  - Test information
  - Revision information
- Changes to the safety-related system, must comply with IEC 61511 standard on process safety section 11.7.1 Operator Interface requirements.
- The developer must follow the same sound development techniques and procedures used for other application software development, including the verification and testing of the operator interface and its access to other parts of the program. The controller application software should set up a table that is accessible by the HMI and limits access to required data points only.
- Similar to the controller program, the HMI software needs to be secured and maintained for SIL-level compliance after the system has been validated and tested.

Notes:

Reaction Times of the ControlLogix System

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Local Chassis Configuration	107
Remote Chassis Configuration	108
Calculating Worst-case Reaction Time	108

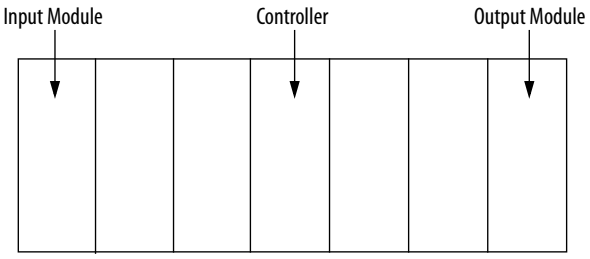
The calculation formulas in this chapter can be used to calculate the worst-case reaction times for a given change in input or fault condition and the corresponding output action.

Local Chassis Configuration

Figure 60 shows an example system with digital or analog modules where the following occurs:

- Field signal changes state.
- The data is transmitted to the controller.
- The controller runs its program scan and reacts to the data change.
- The controller transmits data to the output module.
- The output module processes data from the controller and turns the output device on or off.

Figure 60 - Local Chassis Configuration of Digital or Analog Modules

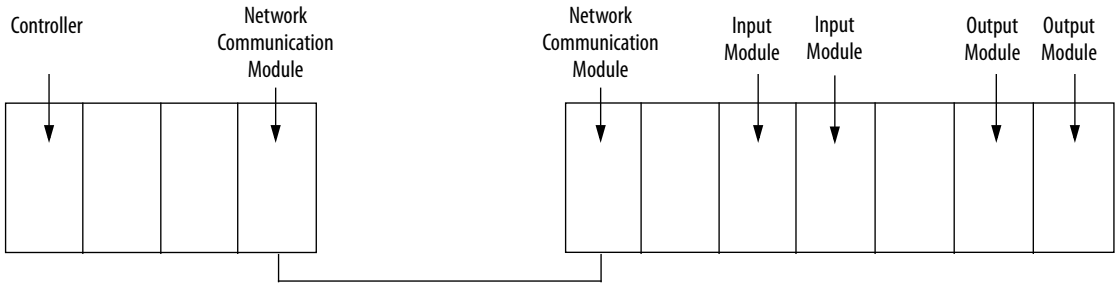


Remote Chassis Configuration

Figure 61 shows an example system where the following occurs:

- Input data changes on the input module.
- The data is transmitted to the controller via the network communication modules.
- The controller runs its program scan and reacts to the data change, including sending new data to the output module via the network communication modules.
- The output module behavior changes based on the new data received from the controller.

Figure 61 - Remote Chassis Configuration of Digital or Analog Modules



Calculating Worst-case Reaction Time

The formulas for calculating worst-case reaction times with no system faults or errors differ slightly for digital or analog I/O modules, as shown in the following sections.

For Digital Modules

Use this formula to determine worst-case reaction time for digital modules in local or remote configurations:

Worst-Case Reaction Time with no faults or errors =
(Input Module Delay + Input Filter Time) + (Input Module RPI x 4/8/16… ≥100 ms)(1) +
(SIL 2 Task Period + SIL 2 Task Watchdog) + (Output Module RPI x 4/8/16… ≥100 ms)(1) +
(Output Module Delay).

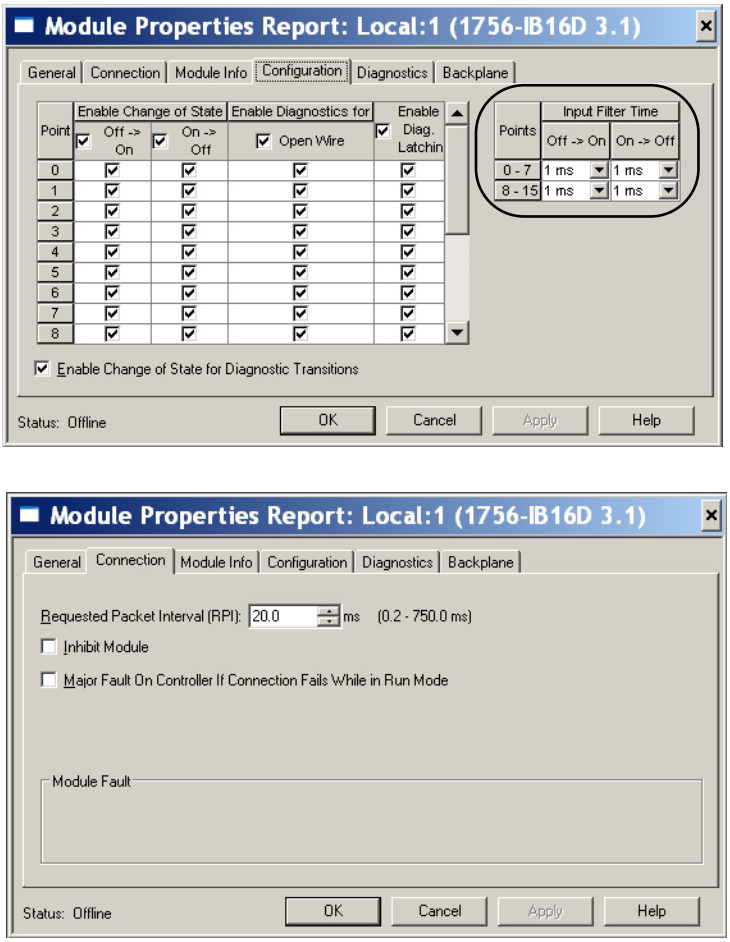
Module delay times are listed in the ControlLogix I/O Modules Specifications Technical Data, publication 1756-TD002.

(1) Multiply the module RPI by 4, then 8, then 16, and so on, until the result is at least 100 ms.

Input filter time is configurable via the Configuration tab on the Module Properties dialog box in the programming software.

- If the safe state in your application is low, use the On -> Off Input Filter Time.
- If the safe state in your application is high, use the Off -> On Input Filter Time.

Figure 62 - Digital Module Configuration



Module RPI is configurable via the Connection tab.

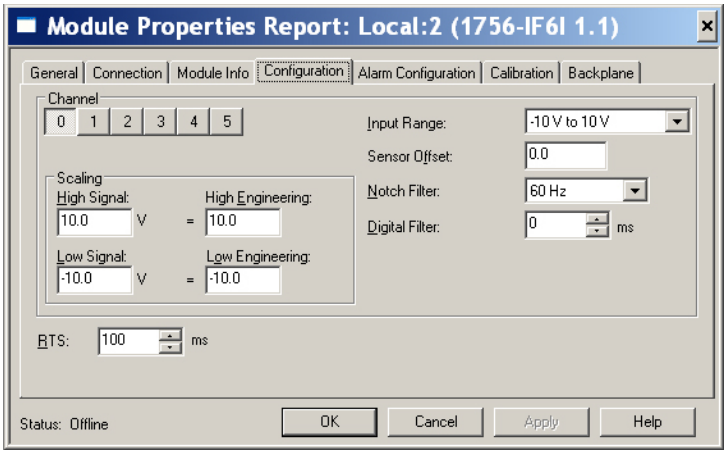
For Analog Modules

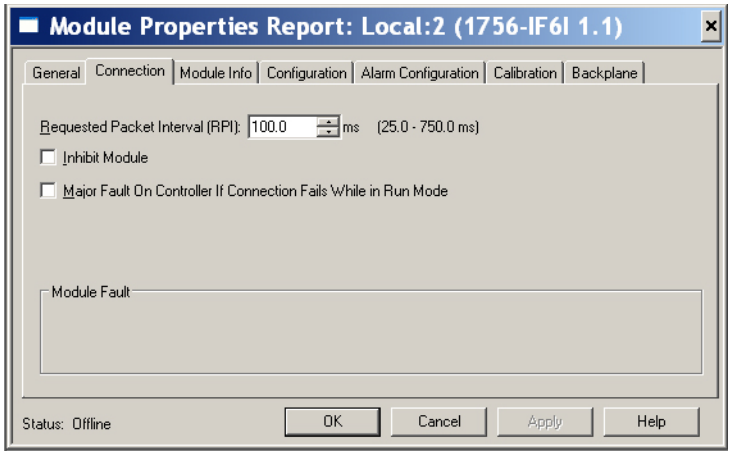
Use this formula to determine worst-case reaction time for analog modules in local or remote configurations:

Worst-Case Reaction Time with no faults or errors =
(Real Time Sample (RTS) Rate) +
(Input Module RPI x 4/8/16… ≥100 ms)[1] + (SIL 2 Task Period + SIL 2 Task Watchdog) +
(Output Module RPI x 4/8/16… ≥100 ms)[1] + (Output Module Delay).

Filter time and RTS are configurable via the Configuration tab on the Module Properties dialog box in the programming software. Module RPI is configurable via the Connection tab.

Figure 63 - Analog Module Configuration





Refer to the ControlLogix Analog I/O Module User Manual, publication 1756-UM009, for information on setting filter and RTS values.

(1) Multiply the module RPI by 4, then 8, then 16, and so on, until the result is at least 100 ms.

SIL 2-certified ControlLogix System Components

System components listed in this appendix are certified according to IEC 61508 2010 Edition 2, unless noted in the following tables.

Use only the series versions listed in Appendix C. These tables list publications related to these components. Publications are available from Rockwell Automation by visiting http://www.rockwellautomation.com/literature.

Table 5 - SIL 2-certified ControlLogix Components - Hardware

Cat. No.(1)	Description	Related Documentation
1756-A4, 1756-A7 1756-A10, 1756-A13, 1756-A17	ControlLogix chassis	1756-IN005
1756-PA75(2)	ControlLogix AC power supply	
1756-PB75(2)	ControlLogix DC power supply	
1756-PA75R	ControlLogix AC redundant power supply	
1756-PB75R	ControlLogix DC redundant power supply	
1756-PA72	ControlLogix AC power supply	
1756-PB72	ControlLogix DC power supply	
1756-PC75	ControlLogix DC power supply	
1756-PH75	ControlLogix DC power supply	
1756-PSCA(3)	ControlLogix redundant power supply chassis adapter module	
1756-PSCA2(3)	ControlLogix redundant power supply chassis adapter module	

(1) Some catalog numbers have a K suffix. This indicates a version of the product that has conformal coating. These K versions have the same SIL 2 certification as the non-K versions. For more information on which products have conformal coating go to http://ab.com.rockwellautomation.com/

(2) The 1756-PA75/A and 1756-PB75/A power supplies are no longer available. However, if your existing SIL 2 application uses these power supplies, they are SIL 2 certified.

(3) Existing systems that use the 1756-PSCA and 1756-PSCA2 are SIL 2-certified. However, when implementing new SIL 2-certified systems or upgrading existing systems, we recommend that you use the 1756-PSCA2 module if possible.

Table 6 - SIL 2-certified ControlLogix Components - 1756 Nonredundant Controllers, I/O, and Communication Modules

Cat. No.[1]	Description	Related Documentation
1756-L61[2] [3]	ControlLogix 2 MB controller	1756-UM001
1756-L62[2] [3]	ControlLogix 4 MB controller	
1756-L63[2] [3]	ControlLogix 8 MB controller	
1756-L71[2]	ControlLogix 2 MB controller	
1756-L72[2]	ControlLogix 4 MB controller	
1756-L73[2]	ControlLogix 8 MB controller	
1756-L74[2]	ControlLogix 16 MB controller	
1756-L75[2]	ControlLogix 32 MB controller	
1756-IA16I	ControlLogix AC isolated input module	1756-UM058
1756-IA8D	ControlLogix AC diagnostic input module	
1756-IB16D	ControlLogix DC diagnostic input module	
1756-IB16I	ControlLogix DC isolated input module	
1756-IB32	ControlLogix DC input module	
1756-IB16ISOE	ControlLogix Sequence of Events module	1756-UM528
1756-IH16ISOE	ControlLogix Sequence of Events module	
1756-OA16I	ControlLogix AC isolated output module	1756-UM058
1756-OA8D	ControlLogix AC diagnostic input module	
1756-OB16D	ControlLogix DC diagnostic output module	
1756-OB16E	ControlLogix DC electronically-fused output module	
1756-OB16I	ControlLogix DC isolated output module	
1756-OB32	ControlLogix DC output module	
1756-OB8EI	ControlLogix DC isolated output module	
1756-OW16I	ControlLogix isolated relay output module	
1756-OX8I	ControlLogix isolated relay output module	
1756-IF8	ControlLogix analog input module	1756-UM009
1756-IF16	ControlLogix analog input module	
1756-IF6I	ControlLogix Isolated analog input module	
1756-IF6CIS	ControlLogix Isolated analog input module	
1756-IF8H	ControlLogix HART analog input module	1756-UM533
1756-IF16H	ControlLogix HART analog input module	

Table 6 - SIL 2-certified ControlLogix Components - 1756 Nonredundant Controllers, I/O, and Communication Modules

Cat. No.(1)	Description	Related Documentation
1756-IR6I	ControlLogix RTD input module	1756-UM009
1756-IT6I	ControlLogix Thermocouple input module	
1756-IT6I2	ControlLogix enhanced Thermocouple input module	
1756-OF8	ControlLogix analog output module	
1756-OF6CI	ControlLogix isolated analog output module	
1756-OF6VI	ControlLogix isolated analog output module	
1756-OF8H	ControlLogix HART analog output module	1756-UM533
1756-CNB(4)	ControlLogix ControlNet communication module	CNET-IN005 CNET-UM001
1756-CN2	ControlLogix ControlNet communication module	
1756-CN2R	ControlLogix redundant media ControlNet communication module	
1786-RPFS	ControlNet short-distance fiber repeater module	1786-IN012
1786-RPFM	ControlNet medium-distance fiber repeater module	1786-IN011
1786-RPFRL	ControlNet long-distance fiber repeater module	1786-IN003
1786-RPFRXL	ControlNet extra-long-distance fiber repeater module	
1786-RPA	ControlNet repeater adapter	1786-IN013
1786-RPCD	ControlNet Hub repeater module	1786-IN001
1756-EN2TR Series B	ControlLogix redundant media EtherNet/IP communication module	ENET-IN002 ENET-UM001
1756-EN2TR Series C	ControlLogix redundant media EtherNet/IP communication module	
1756-EN2T Series C	ControlLogix EtherNet/IP communication module	

(1) Some catalog numbers have a K suffix. This indicates a version of the product that has conformal coating. These K versions have the same SIL 2 certification as the non-K versions. For more information on which products have conformal coating go to http://ab.com.rockwellautomation.com/

(2) Use of any series B controller requires the use of the series B versions of the 1756-Px75 power supplies.

(3) Certified according to IEC 61508 1999 Edition 1.

(4) Specified ControlNet repeaters may be used in SIL 2 applications. See Chapter 4, ControlLogix Communication Modules for more information.

Table 7 - SIL 2-certified ControlLogix Components - 1756 Redundancy System Components

Cat. No.[1]	Description	Related Documentation
1756-L61[2] [3]	ControlLogix 2 MB controller	1756-UM001
1756-L62[2] [3]	ControlLogix 4 MB controller	
1756-L63[2] [3]	ControlLogix 8 MB controller	
1756-L71[2]	ControlLogix 2 MB controller	
1756-L72[2]	ControlLogix 4 MB controller	
1756-L73[2]	ControlLogix 8 MB controller	
1756-L74[2]	ControlLogix 16 MB controller	
1756-L75[2]	ControlLogix 32 MB controller	
1756-CNB	ControlLogix ControlNet communication module	CNET-IN005 CNET-UM001
1756-CNBR	ControlLogix redundant media ControlNet communication module	
1756-CN2	ControlLogix ControlNet communication module	
1756-CN2R	ControlLogix redundant media ControlNet communication module	
1756-EN2T Series C	ControlLogix EtherNet/IP communication module	ENET-IN002 ENET-UM001
1756-EN2TR Series B	ControlLogix redundant media EtherNet/IP communication module	
1756-EN2TR Series C		

(1) Some catalog numbers have a K suffix. This indicates a version of the product that has conformal coating. These K versions have the same SIL 2 certification as the non-K versions. For more information on which products have conformal coating go to http://ab.com.rockwellautomation.com/

(2) Use of any series B controller requires the use of the series B versions of the 1756-P*x*75 power supplies or the redundant power supplies, that is, the 1756-L*x*75R power supplies.

(3) Certified according to IEC 61508 1999 Edition 1.

Table 8 - SIL 2-certified ControlLogix-XT System Components

Cat. No.	Description	Related Documentation
1756-A4LXT 1756-A5XT, 1756-A7XT 1756-A7LXT	ControlLogix-XT chassis	1756-IN005
1756-PAXT 1756-PBXT	ControlLogix-XT power supply	
1756-CN2RXT	ControlLogix-XT ControlNet communication module	CNET-IN005 CNET-UM001
1756-EN2TXT Series C	ControlLogix-XT EtherNet/IP communication module	ENET-IN002 ENET-UM001
1756-EN2TRXT Series C	ControlLogix-XT EtherNet/IP communication module for redundant systems	
1756-L63XT[1]	ControlLogix-XT controller	1756-UM001
1756-L73XT	ControlLogix-XT controller	

(1) Certified according to IEC 61508 1999 Edition 1.

IMPORTANT

ControlLogix-XT™ modules use the same firmware as traditional ControlLogix components. When obtaining firmware for ControlLogix-XT modules, download and use the firmware specific to each module.

For example, if you are using a 1756-EN2TXT module in your system, use SIL 2-certified firmware for the 1756-EN2T module.

For more information about ControlLogix-XT module firmware revisions, see the firmware release notes specific to the module. ControlLogix-XT module release notes are available at: http://www.rockwellautomation.com/literature or http://www.rockwellautomation.com/support/.

Table 9 - FLEX I/O Components For Use in the SIL 2 System

Cat. No.(1)	Description	Related Documentation(2)
1794-ACN15	FLEX I/O ControlNet single media adapter	1794-IN128
1794-ACNR15	FLEX I/O ControlNet redundant media adapter	
1794-ACNR15XT	FLEX I/O-XT™ ControlNet redundant media adapter	
1794-AENT	FLEX I/O EtherNet/IP communication adapter	1794-IN082
1794-AENTR	FLEX I/O EtherNet/IP redundant communication adapter	1794-IN131
1794-AENTRXT	FLEX I/O-XT EtherNet/IP redundant communication adapter	
1794-IB16	FLEX I/O input module	1794-IN093
1794-IB16XT	FLEX I/O-XT input module	1794-IN124
1794-IB10XOB6	FLEX I/O input/output module	1794-IN083
1794-IB10XOB6XT	FLEX I/O-XT input/output module	1794-IN124
1794-OB16	FLEX I/O output module	1794-IN094
1794-OB16P	FLEX I/O protected output module	1794-IN094
1794-OB16PXT	FLEX I/O-XT protected output module	1794-IN124
1794-OB8EP	FLEX I/O electronically-fused output module	1794-IN094
1794-OB8EPXT	FLEX I/O-XT electronically-fused output module	1794-IN124
1794-OW8	FLEX I/O relay output module	1794-IN019
1794-OW8XT	FLEX I/O-XT relay output module	
1794-IE8	FLEX I/O analog input module	1794-IN100 1794-UM002
1794-IF4I	FLEX I/O isolated analog input module	1794-IN038 1794-UM008
1794-IF4IXT	FLEX I/O-XT isolated analog input module	1794-IN129 1794-UM008
1794-IF4ICFXT	FLEX I/O-XT isolated analog input module	1794-IN130 1794-UM008
1794-IF2XOF2I	FLEX I/O isolated analog input/output module	1794-IN039 1794-UM008
1794-IF2XOF2IXT	FLEX I/O-XT isolated analog input/output module	1794-IN129 1794-UM008
1794-OE4	FLEX I/O analog output module	1794-IN100 1794-UM002
1794-OF4I	FLEX I/O isolated analog output module	1794-IN037 1794-UM008
1794-IT8	FLEX I/O Thermocouple input module	1794-IN021 1794-UM007

Table 9 - FLEX I/O Components For Use in the SIL 2 System

Cat. No.[1]	Description	Related Documentation[2]
1794-IR8	FLEX I/O RTD input module	1794-IN021 1794-UM004
1794-IR8XT	FLEX I/O-XT RTD input module	
1794-IRT8	FLEX I/O Thermocouple/RTD input module	1794-IN050 1794-UM012
1794-IRT8XT	FLEX I/O-XT Thermocouple/RTD analog input module	
1794-IJ2	FLEX I/O counter module	1794-IN049 1794-UM011
1794-IJ2XT	FLEX I/O-XT counter module	
1794-IP4	FLEX I/O counter module	1794-IN064 1794-UM016
1794-IE4XOE2XT	FLEX I/O-XT analog input/output module	1794-IN125
1794-IE8XT	FLEX I/O-XT analog input module	1794-IN125
1794-OE4XT	FLEX I/O-XT analog output module	1794-IN125
1794-OF4IXT	FLEX I/O-XT isolated analog output module	1794-IN129 1794-UM008
1794-TB3	FLEX I/O terminal base unit	1794-IN092
1794-TB3S	FLEX I/O terminal base unit	
1794-TB3T	FLEX I/O temperature terminal base unit	
1794-TB3TS	FLEX I/O spring-clamp temperature terminal base unit	
1794-TB3G	FLEX I/O cage-clamp generic terminal base unit	
1794-TB3GS	FLEX I/O spring-clamp generic terminal base unit	
1794-TBN	FLEX I/O NEMA terminal base unit	
1794-TBNF	FLEX I/O NEMA fused terminal base unit	

(1) Some catalog numbers have a K suffix. This indicates a version of the product that has conformal coating. These K versions have the same SIL 2 certification as the non-K versions. For more information on which products have conformal coating go to http://ab.com.rockwellautomation.com/

(2) These publications are available from Rockwell Automation by visiting http://www.rockwellautomation.com/literature.

PFD and PFH Calculations for a SIL 2 System

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About PFD and PFH Calculations

Probability of failure on demand (PFD) is the SIL value for a safety-related system as related directly to order-of-magnitude ranges of its average probability of failure to satisfactorily perform its safety function on demand. IEC 61508 quantifies this classification by stating that the frequency of demands for operation of the safety system is no greater than once per year in the Low Demand mode.

PFD calculations are commonly used for process safety applications and applications where emergency stop devices (ESDs) are used.

Although PFD values are usually associated with each of the three elements making up a safety-related system (the sensors, the actuators, and the logic element), they can be associated with each component of the logic element, that is, each module of a programmable controller.

Probability of failure per hour (PFH) is typically used to describe safety performance for high demand applications. Because ControlLogix is suitable for high demand applications up to and including 10 demands per year, PFH values for those applications are provided.

Tables in this chapter present PFD and PFH values for ControlLogix and ControlLogix-XT components that are evaluated by TÜV.

Determine Which Values To Use

IMPORTANT You are responsible for determining which of the values provided are appropriate for your SIL 2-certified system. Determine which values to use based on the modules used your system and the system configuration.

Each of the PFD and PFH calculated values provided in this manual is based on the configuration that the module can be used in, that is 1oo1 or 1oo2.

- Communication and controller communication modules have PFD values specific to use in a 1oo1 configuration.
- Input or output modules have PFD values specific to use in a 1oo2 configuration.

About the Calculations in This Manual

For the calculations presented in this chapter, these values were used as the two application-dependent variables:

- Mean time to restoration (MTTR) is ten hours.
- Proof test interval (T_1) is listed for each table.

Common Terms
λ = failure rate = 1/MTBF
λ_s = rate of safe failures = λ x 50%
λ_d = rate of dangerous failures = λ x 50%
λ_{dd}= dangerous, detected failure rate = λ/2 x DC
λ_{du}= dangerous, undetected failure rate = λ/2 x (1-DC)
SFF = safe failure fraction =$(\lambda_s + \lambda_{dd})/\lambda$
T_{CE1oo1} = channel equivalent down time = λ_{du}/λ_d x (T_1/2 + MRT) + (λ_d/λ_d x MTTR)
DC = diagnostic coverage
ß = common cause failure rate
$ß_d$ = common cause failure rate, dangerous
1oo1 Configuration
STR_{1oo1} = spurious trip rate = $\lambda_s + \lambda_{dd}$
$PFD_{1oo1} = (\lambda_{dd} + \lambda_{du}) \times T_{CE}$
$PFH_{1oo1} = \lambda_{du}$
1oo2 Configuration
STR_{1oo2} = spurious trip rate = 2 x ($\lambda_s + \lambda_{dd}$)
T_{GE1oo2} = system equivalent down time = $\lambda_{du/} \lambda_d$ x (T_1/3 + MRT) + ($\lambda_{dd/} \lambda_d$ x MTTR)
PFD_{1oo2}= 2 x $[(1-ß_D) \times \lambda_{dd} + (1-ß) \times \lambda_{du}]^2 \times T_{CE} \times T_{GE} + (ß_D \times \lambda_{dd} \times MTTR) + ß \times \lambda_{du} \times (T_1/2 + MRT)$
$PFH_{1oo2} = 2 \times [(1-ß_D) \times \lambda_{dd} + (1-ß) \times \lambda_{du}] \times (1-ß) \times \lambda_{du} \times T_{CE} + ß \times \lambda_{du}$

The PFD and PFH values in this manual are calculated with formulas explained in IEC 61508, Part 6, Annex B. Refer to IEC 61508, Part 6, for more information about calculating PFD values for your system.

1-Year PFD Calculations

The PFD calculations in this table are calculated for a 1-year proof test interval (8760 hours) and are specific to ControlLogix system components.

Table 10 - 1- Year PFD Calculations

Cat No.[1]	Series	Firmware Version[6]	Description	Mean Time between Failure (MTBF)[7]	Common Terms[8]						1oo1 Configuration			1oo2 Configuration			
					λ[9]	λ_s, λ_d	Safe Failure Fraction (SFF)	λ_{du}	λ_{dd}	T_{CE1oo1}	Spurious Trip Rate STR	PFH[10]	PFD	Spurious Trip Rate STR	T_{GE}	PFH[10]	PFD
1756-AXX[2]	C	Not Applicable	ControlLogix chassis	22,652,010	4.41E-08	2.21E-08	95%	2.21E-09	1.99E-08	448	4.19E-08	2.21E-09	9.89E-06	Not Applicable			
1756-A4LXT	B		4-slot ControlLogix-XT chassis	1,069,120	9.35E-07	4.68E-07	95%	4.68E-08	4.21E-07	448	8.89E-07	4.68E-08	2.10E-04				
1756-A5XT	C		5-slot ControlLogix-XT chassis	734,420	1.36E-06	6.81E-07	95%	6.81E-08	6.13E-07	448	1.29E-06	6.81E-08	3.05E-04				
1756-A7LXT	B		7-slot ControlLogix-XT chassis	27,628,178	3.62E-08	1.81E-08	95%	1.81E-09	1.63E-08	448	3.44E-08	1.81E-09	8.11E-06				
1756-A7XT	C		7-slot ControlLogix-XT chassis	1,081,600	9.25E-07	4.62E-07	95%	4.62E-08	4.16E-07	448	8.78E-07	4.62E-08	2.07E-04				
1756-PB72	C		18-32V DC 10A ControlLogix power supply	31,561,095	3.17E-08	1.58E-08	95%	1.58E-09	1.43E-08	448	3.01E-08	1.58E-09	7.10E-06				
1756-PA72	C		85-265V AC 10A ControlLogix power supply	18,336,146	5.45E-08	2.73E-08	95%	2.73E-09	2.45E-08	448	5.18E-08	2.73E-09	1.22E-05				
1756-PA75	B		85-265V AC 13A ControlLogix power supply (75W)	18,693,044	5.35E-08	2.67E-08	95%	2.67E-09	2.41E-08	448	5.08E-08	2.67E-09	1.20E-05				
1756-PA75R	A		85-265V AC 13A Redundant ControlLogix power supply	1,412,877	7.08E-07	3.54E-07	95%	3.54E-08	3.18E-07	448	6.72E-07	3.54E-08	1.59E-04				
1756-PB75	B		18-32V DC 13A ControlLogix power supply	15,675,475	6.38E-08	3.19E-08	95%	3.19E-09	2.87E-08	448	6.06E-08	3.19E-09	1.43E-05				
1756-PB75R	A		18-32V DC 13A Redundant ControlLogix power supply	1,736,020	5.76E-07	2.88E-07	95%	2.88E-08	2.59E-07	448	5.47E-07	2.88E-08	1.29E-04				
1756-PAXT	B		ControlLogix-XT AC power supply	18,693,044	5.35E-08	2.67E-08	95%	2.67E-09	2.41E-08	448	5.08E-08	2.67E-09	1.20E-05				
1756-PBXT	B		ControlLogix-XT DC power supply	1,855,360	5.39E-07	2.69E-07	95%	2.69E-08	2.43E-07	448	5.12E-07	2.69E-08	1.21E-04				
1756-PC75	B		30-60V DC 13A ControlLogix power supply	5,894,836	1.70E-07	8.48E-08	95%	8.48E-09	7.63E-08	448	1.61E-07	8.48E-09	3.80E-05				
1756-PH75	B		90-143V DC 13A ControlLogix power supply	2,119,520	4.72E-07	2.36E-07	95%	2.36E-08	2.12E-07	448	4.48E-07	2.36E-08	1.06E-04				
1756-PSCA	A		Redundant power supply adapter	45,146,727	2.21E-08	1.11E-08	95%	1.11E-09	9.97E-09	448	2.10E-08	1.11E-09	4.96E-06				
1756-PSCA2	A		Redundant power supply adapter	38,461,280	2.60E-08	1.30E-08	95%	1.30E-09	1.17E-08	448	2.47E-08	1.30E-09	5.82E-06				
1786-RPFS	A		ControlNet Fiber repeater - short	26,461,760	3.78E-08	1.89E-08	95%	1.89E-09	1.70E-08	448	3.59E-08	1.89E-09	8.47E-06				
1786-RPFM	A		ControlNet Fiber repeater - medium	16,697,862	5.99E-08	2.99E-08	95%	2.99E-09	2.69E-08	448	5.69E-08	2.99E-09	1.34E-05				
1786-RPFRL	A		ControlNet Fiber repeater - long	5,717,227	1.75E-07	8.75E-08	95%	8.75E-09	7.87E-08	448	1.66E-07	8.75E-09	3.92E-05				
1786-RPCD	A		ControlNet Hub repeater	28,654,080	3.49E-08	1.74E-08	95%	1.74E-09	1.57E-08	448	3.32E-08	1.74E-09	7.82E-06				
1786-RPA	B		ControlNet repeater adapter	11,826,146	8.46E-08	4.23E-08	95%	4.23E-09	3.81E-08	448	8.03E-08	4.23E-09	1.89E-05				
1786-RPFRXL	B		ControlNet Fiber repeater - extra long	11,373,440	8.79E-08	4.40E-08	95%	4.40E-09	3.96E-08	448	8.35E-08	4.40E-09	1.97E-05				
1756-L61[3]	B	20.012 20.055	ControlLogix controller, 2MB	1,000,053	1.00E-06	5.00E-07	95%	5.00E-08	4.50E-07	448	9.50E-07	5.00E-08	2.24E-04	Not Applicable			
1756-L62[3]	B	20.012 20.055	ControlLogix controller, 4MB	1,034,830	9.66E-07	4.83E-07	95%	4.83E-08	4.35E-07	448	9.18E-07	4.83E-08	2.16E-04				
1756-L63[3]	B	20.012 20.055	ControlLogix controller, 8MB	1,055,910	9.47E-07	4.74E-07	95%	4.74E-08	4.26E-07	448	9.00E-07	4.74E-08	2.12E-04				
1756-L63XT[3]	B	20.012 20.055	ControlLogix-XT controller, 8MB	357,760	2.80E-06	1.40E-06	95%	1.40E-07	1.26E-06	448	2.66E-06	1.40E-07	6.26E-04				
1756-L71[4]	B	20.012 20.055	ControlLogix controller, 2MB	Calculated MTBF and PFD via FMEA	2.69E-06	1.34E-06	96%	1.01E-07	1.25E-06	340	2.91E-06	1.01E-07	4.50E-04	Not Applicable			
1756-L72[4]	B	20.012 20.055	ControlLogix controller, 4MB		2.69E-06	1.34E-06	96%	1.01E-07	1.25E-06	340	2.91E-06	1.01E-07	4.50E-04				
1756-L73[4]	B	20.012 20.055	ControlLogix controller, 8MB		2.69E-06	1.34E-06	96%	1.01E-07	1.25E-06	340	2.91E-06	1.01E-07	4.50E-04				
1756-L73XT[4]	B	20.012 20.055	ControlLogix-XT controller, 8MB		2.69E-06	1.34E-06	96%	1.01E-07	1.25E-06	340	2.91E-06	1.01E-07	4.50E-04				
1756-L74[4]	B	20.012 20.055	ControlLogix controller, 16MB		2.69E-06	1.34E-06	96%	1.01E-07	1.25E-06	340	2.91E-06	1.01E-07	4.50E-04				
1756-L75[4]	B	20.012 20.055	ControlLogix controller, 32MB		2.69E-06	1.34E-06	96%	1.01E-07	1.25E-06	340	2.91E-06	1.01E-07	4.50E-04				

Table 10 - 1- Year PFD Calculations

Cat No.[1]	Series	Firmware Version[6]	Description	Mean Time between Failure (MTBF)[7]	Common Terms[8]						1oo1 Configuration			1oo2 Configuration			
					λ[9]	λ_s , λ_d	Safe Failure Fraction (SFF)	λ_{du}	λ_{dd}	T_{CE1oo1}	Spurious Trip Rate STR	PFH[10]	PFD	Spurious Trip Rate STR	T_{GE}	PFH[10]	PFD
1756-CNB	E	11.005	ControlLogix ControlNet communication module	1,786,977	5.60E-07	2.80E-07	95%	2.80E-08	2.52E-07	448	5.32E-07	2.80E-08	1.25E-04				
1756-CNBR	E	11.005	ControlLogix ControlNet redundant communication module	2,608,543	3.83E-07	1.92E-07	95%	1.92E-08	1.73E-07	448	3.64E-07	1.92E-08	8.59E-05				
1756-CN2	B	20.011	ControlLogix ControlNet communication module	1,096,299	9.12E-07	4.56E-07	95%	4.56E-08	4.10E-07	448	8.67E-07	4.56E-08	2.04E-04				
1756-CN2	C	25.004	ControlLogix ControlNet communication module	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	303.63	1.91E-06	6.62E-08	3.0E-04				
1756-CN2R	B	20.011	ControlLogix ControlNet redundant communication module	1,096,299	9.12E-07	4.56E-07	95%	4.56E-08	4.10E-07	448	8.67E-07	4.56E-08	2.04E-04	Not Applicable			
1756-CN2R	C	25.004	ControlLogix ControlNet redundant communication module	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	303.63	1.91E-06	6.62E-08	3.0E-04				
1756-CN2RXT	B	20.011	ControlLogix-XT ControlNet redundant communication module	1,980,160	5.05E-07	2.53E-07	95%	2.53E-08	2.27E-07	448	4.80E-07	2.53E-08	1.13E-04				
1756-CN2RXT	C	25.004	ControlLogix-XT ControlNet redundant communication module	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	303.63	1.91E-06	6.62E-08	3.0E-04				
1756-DHRIO[5]	E	7.002	ControlLogix Data Highway Plus Remote I/O Module	2,503,396	Non-interference only						2.90E-07	Not applicable		5.79E-07	Not applicable		
1756-DHRIOXT[5]	E	7.002	ControlLogix-XT Data Highway Plus Remote I/O Module	2,503,396							2.90E-07			5.79E-07			
1756-DNB[5]	D	12.005	ControlLogix DeviceNet communication module	2,192,202							3.31E-07			6.61E-07			
1756-ENBT[5]	A	4.008 6.006	ControlLogix EtherNet/IP communication module	2,088,198							3.47E-07			6.94E-07			
1756-EN2T	C	5.008	ControlLogix EtherNet/IP communication module	1,312,712	7.62E-07	3.81E-07	95%	3.81E-08	3.43E-07	448	7.24E-07	3.81E-08	1.71E-04				
1756-EN2T	D	10.007	ControlLogix EtherNet/IP communication module	269,774	Non-interference only						3.71E-06	Not applicable		Not applicable			
1756-EN2TR	B	5.008	ControlLogix EtherNet/IP communication module with fault tolerance	3,664,960	2.73E-07	1.36E-07	95%	1.36E-08	1.23E-07	448	2.59E-07	1.36E-08	6.11E-05				
1756-EN2TR	C	10.006	ControlLogix EtherNet/IP communication module with fault tolerance	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	303.63	1.91E-06	6.62E-08	3.0E-04	3.82E-06	258.2	1.36E-09	6.11E-06
1756-EN2TRXT	C	10.006	ControlLogix EtherNet/IP communication module with fault tolerance		1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	303.63	1.91E-06	6.62E-08	3.0E-04	3.82E-06	258.2	1.36E-09	6.11E-06
1756-EN2TXT	C	5.008	ControlLogix-XT EtherNet/IP communication module	1,300,000	7.69E-07	3.85E-07	95%	3.85E-08	3.46E-07	448	7.31E-07	3.85E-08	1.72E-04	Not applicable			
1756-EN2TXT	D	10.007	ControlLogix-XT EtherNet/IP communication module	269,774	Non-interference only						3.71E-06	Not applicable					
1756-EN3TR	B	10.007	ControlLogix EtherNet/IP communication module with fault tolerance	269,774							3.71E-06						
1756-RM[5]	B	3.003	ControlLogix redundancy module	1,373,840							7.28E-07						
1756-RM2	A	20.004	ControlLogix enhanced redundancy module	250,182							4.00E-06						
1756-RM2XT	A	20.004	ControlLogix-XT enhanced redundancy module	250,182							4.00E-06						
1756-RMXT[5]	B	3.003	ControlLogix-XT redundancy module	980,096							1.02E-06						
1756-SYNCH[5]	A	2.018	ControlLogix SyncLink Module	6,932,640							1.05E-07	Not applicable		2.09E-07	Not applicable		
1756-IA16I	A	3.003	ControlLogix isolated V AC input module	20,801,920	4.81E-08	2.40E-08	80%	9.61E-09	1.44E-08	1762	3.85E-08	9.61E-09	4.24E-05	7.69E-08	1178	4.81E-10	2.12E-06
1756-IA8D	A	3.003	ControlLogix diagnostic V AC input module	15,966,080	6.26E-08	3.13E-08	80%	1.25E-08	1.88E-08	1762	5.01E-08	1.25E-08	5.52E-05	1.00E-07	1178	6.28E-10	2.76E-06
1756-IB16D	A	3.003	ControlLogix diagnostic V DC input module	30,228,640	3.31E-08	1.65E-08	80%	6.62E-09	9.92E-09	1762	2.65E-08	6.62E-09	2.91E-05	5.29E-08	1178	3.31E-10	1.46E-06
1756-IB16I	A	3.003	ControlLogix isolated V DC input module	81,443,094	1.23E-08	6.14E-09	80%	2.46E-09	3.68E-09	1762	9.82E-09	2.46E-09	1.08E-05	1.96E-08	1178	1.23E-10	5.41E-07

Table 10 - 1- Year PFD Calculations

Cat No.[1]	Series	Firmware Version[6]	Description	Mean Time between Failure (MTBF)[7]	Common Terms[8]						1oo1 Configuration			1oo2 Configuration			
					λ[9]	λ_s , λ_d	Safe Failure Fraction (SFF)	λ_{du}	λ_{dd}	T_{CE1oo1}	Spurious Trip Rate STR	PFH[10]	PFD	Spurious Trip Rate STR	T_{GE}	PFH[10]	PFD
1756-IB16ISOE	A	2.007	ControlLogix isolated V DC Sequence Of Events input module	11,537,760	8.67E-08	4.33E-08	80%	1.73E-08	2.60E-08	1762	6.93E-08	1.73E-08	7.64E-05	1.39E-07	1178	8.69E-10	3.82E-06
1756-IB32	B	3.005	ControlLogix V DC input module	10,462,329	9.56E-08	4.78E-08	80%	1.91E-08	2.87E-08	1762	7.65E-08	1.91E-08	8.42E-05	1.53E-07	1178	9.59E-10	4.22E-06
1756-IF8	A	1.005	ControlLogix analog input module	8,699,254	1.15E-07	5.75E-08	80%	2.30E-08	3.45E-08	1762	9.20E-08	2.30E-08	1.01E-04	1.84E-07	1178	1.15E-09	5.08E-06
1756-IF8H	A	1.002	ControlLogix HART analog input module	1,291,978	7.74E-07	3.87E-07	80%	1.55E-07	2.32E-07	1762	6.19E-07	1.55E-07	6.82E-04	1.24E-06	1178	7.93E-09	3.47E-05
1756-IF16	A	1.005	ControlLogix analog input module	4,592,506	2.18E-07	1.09E-07	80%	4.35E-08	6.53E-08	1762	1.74E-07	4.35E-08	1.92E-04	3.48E-07	1178	2.19E-09	9.64E-06
1756-IF16H	A	1.002	ControlLogix HART analog input module	442,914	2.26E-06	1.13E-06	80%	4.52E-07	6.77E-07	1762	1.81E-06	4.52E-07	1.99E-03	3.61E-06	1178	2.42E-08	1.04E-04
1756-IF6CIS	A	1.013	ControlLogix isolated analog input module	2,654,080	3.77E-07	1.88E-07	80%	7.54E-08	1.13E-07	1762	3.01E-07	7.54E-08	3.32E-04	6.03E-07	1178	3.81E-09	1.67E-05
1756-IF6I	A	1.013	ControlLogix isolated analog input module	4,176,185	2.39E-07	1.20E-07	80%	4.79E-08	7.18E-08	1762	1.92E-07	4.79E-08	2.11E-04	3.83E-07	1178	2.41E-09	1.06E-05
1756-IH16ISOE	A	2.007	ControlLogix V DC Sequence Of Events input module	2,150,720	4.65E-07	2.32E-07	80%	9.30E-08	1.39E-07	1762	3.72E-07	9.30E-08	4.10E-04	7.44E-07	1178	4.72E-09	2.07E-05
1756-IR6I	A	1.013	ControlLogix isolated RTD input module	4,268,525	2.34E-07	1.17E-07	80%	4.69E-08	7.03E-08	1762	Not allowed for 1oo1 configurations			3.75E-07	1178	2.36E-09	1.04E-05
1756-IT6I	A	1.013	ControlLogix isolated thermocouple input module	3,957,824	2.53E-07	1.26E-07	80%	5.05E-08	7.58E-08	1762				4.04E-07	1178	2.55E-09	1.12E-05
1756-IT6I2	A	1.013	ControlLogix isolated enhanced thermocouple input module	2,720,046	3.68E-07	1.84E-07	80%	7.35E-08	1.10E-07	1762				5.88E-07	1178	3.72E-09	1.63E-05
1756-OA16I	A	3.002	ControlLogix V AC output module	32,891,456	3.04E-08	1.52E-08	80%	6.08E-09	9.12E-09	1762	2.43E-08	6.08E-09	2.68E-05	4.86E-08	1178	3.04E-10	1.34E-06
1756-OA8D	A	3.003	ControlLogix V AC diagnostic output module	11,311,040	8.84E-08	4.42E-08	80%	1.77E-08	2.65E-08	1762	7.07E-08	1.77E-08	7.79E-05	1.41E-07	1178	8.87E-10	3.90E-06
1756-OB16D	A	3.002	ControlLogix V DC diagnostic output module	8,884,374	1.13E-07	5.63E-08	80%	2.25E-08	3.38E-08	1762	9.00E-08	2.25E-08	9.92E-05	1.80E-07	1178	1.13E-09	4.97E-06
1756-OB16E	A	3.003	ControlLogix V DC electronic ally-fused output module	14,997,714	6.67E-08	3.33E-08	80%	1.33E-08	2.00E-08	1762	5.33E-08	1.33E-08	5.87E-05	1.07E-07	1178	6.68E-10	2.94E-06
1756-OB16I	A	3.002	ControlLogix V DC isolated output module	7,388,160	1.35E-07	6.77E-08	80%	2.71E-08	4.06E-08	1762	1.08E-07	2.71E-08	1.19E-04	2.17E-07	1178	1.36E-09	5.98E-06
1756-OB32	A	3.002	ControlLogix V DC output module	2,681,316	3.73E-07	1.86E-07	80%	7.46E-08	1.12E-07	1762	2.98E-07	7.46E-08	3.29E-04	5.97E-07	1178	3.77E-09	1.66E-05
1756-OB8EI	A	3.002	ControlLogix V DC isolated electronic ally-fused output module	14,019,200	7.13E-08	3.57E-08	80%	1.43E-08	2.14E-08	1762	5.71E-08	1.43E-08	6.28E-05	1.14E-07	1178	7.15E-10	3.15E-06
1756-OX8I	A	3.002	ControlLogix isolated relay output module	6,059,635	1.65E-07	8.25E-08	80%	3.30E-08	4.95E-08	1762	1.32E-07	3.30E-08	1.45E-04	2.64E-07	1178	1.66E-09	7.29E-06
1756-OW16I	A	3.002	ControlLogix isolated relay output module	13,695,899	7.30E-08	3.65E-08	80%	1.46E-08	2.19E-08	1762	5.84E-08	1.46E-08	6.43E-05	1.17E-07	1178	7.32E-10	3.22E-06
1756-OF8	A	1.005	ControlLogix analog output module	10,629,795	9.41E-08	4.70E-08	80%	1.88E-08	2.82E-08	1762	7.53E-08	1.88E-08	8.29E-05	1.51E-07	1178	9.44E-10	4.15E-06
1756-OF6VI	A	1.013	ControlLogix isolated analog output module	21,604,960	4.63E-08	2.31E-08	80%	9.26E-09	1.39E-08	1762	3.70E-08	9.26E-09	4.08E-05	7.41E-08	1178	4.64E-10	2.04E-06
1756-OF6CI	A	1.013	ControlLogix isolated analog output module	8,354,667	1.20E-07	5.98E-08	80%	2.39E-08	3.59E-08	1762	9.58E-08	2.39E-08	1.05E-04	1.92E-07	1178	1.20E-09	5.29E-06
1756-OF8H	A	1.002	ControlLogix HART analog output module	5,118,187	1.95E-07	9.77E-08	80%	3.91E-08	5.86E-08	1762	1.56E-07	3.91E-08	1.72E-04	3.13E-07	1178	1.97E-09	8.64E-06
1794-ACN15	D	10.003	FLEX I/O ControlNet adapter	8,223,684	1.22E-07	6.08E-08	80%	2.43E-08	3.65E-08	1762	Not allowed for 1oo1 configurations			1.95E-07	1178	1.22E-09	5.37E-06
1794-ACNR15	D	10.003	FLEX I/O ControlNet redundant adapter	8,223,684	1.22E-07	6.08E-08	80%	2.43E-08	3.65E-08	1762				1.95E-07	1178	1.22E-09	5.37E-06
1794-ACNR15XT	D	10.003	FLEX I/O-XT ControlNet adapter	8,223,684	1.22E-07	6.08E-08	80%	2.43E-08	3.65E-08	1762				1.95E-07	1178	1.22E-09	5.37E-06
1794-AENT	B	4.003	FLEX I/O EtherNET/IP adapter	1,779,827	5.62E-07	2.81E-07	80%	1.12E-07	1.69E-07	1762				8.99E-07	1178	5.72E-09	2.50E-05
1794-AENTR	A	1.013	FLEX I/O EtherNET/IP adapter, Ring media	1,268,070	7.89E-07	3.94E-07	80%	1.58E-07	2.37E-07	1762				1.26E-06	1178	8.08E-09	3.53E-05
1794-AENTRXT	A	1.013	FLEX I/O EtherNET/IP adapter, Ring media	1,268,070	7.89E-07	3.94E-07	80%	1.58E-07	2.37E-07	1762				1.26E-06	1178	8.08E-09	3.53E-05

Table 10 - 1- Year PFD Calculations

Cat No.[1]	Series	Firmware Version[6]	Description	Mean Time between Failure (MTBF)[7]	Common Terms[8]						1oo1 Configuration			1oo2 Configuration			
					λ[9]	λ_s , λ_d	Safe Failure Fraction (SFF)	λ_{du}	λ_{dd}	T_{CE1oo1}	Spurious Trip Rate STR	PFH[10]	PFD	Spurious Trip Rate STR	T_{GE}	PFH[10]	PFD
1794-IB16	A	Not Applicable	FLEX I/O 24V DC input module	179,506,158	5.57E-09	2.79E-09	80%	1.11E-09	1.67E-09	1762				8.91E-09	1178	5.57E-11	2.45E-07
1794-IB16XT	A		FLEX I/O-XT 24V DC input module	35,587,189	2.81E-08	1.40E-08	80%	5.62E-09	8.43E-09	1762				4.50E-08	1178	2.81E-10	1.24E-06
1794-IJ2	A	D	FLEX I/O counter module	55,344,640	1.81E-08	9.03E-09	80%	3.61E-09	5.42E-09	1762	Not allowed for 1oo1 configurations			2.89E-08	1178	1.81E-10	7.96E-07
1794-IJ2XT	A	E	FLEX I/O-XT counter module	11,714,128	8.54E-08	4.27E-08	80%	1.71E-08	2.56E-08	1762				1.37E-07	1178	8.56E-10	3.77E-06
1794-IP4	B	4	FLEX I/O counter module	22,027,200	4.54E-08	2.27E-08	80%	9.08E-09	1.36E-08	1762				7.26E-08	1178	4.55E-10	2.00E-06
1794-IB10XOB6	A	Not Applicable	FLEX I/O 24V DC input/output module	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	1762				1.60E-08	1178	1.00E-10	4.41E-07
1794-IB10XOB6XT	A		FLEX I/O-XT 24V DC input/output module	22,202,487	4.50E-08	2.25E-08	80%	9.01E-09	1.35E-08	1762				7.21E-08	1178	4.51E-10	1.99E-06
1794-OB8EP	A		FLEX I/O 24V DC electronically-fused output module	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	1762	Not allowed for 1oo1 configurations			1.60E-08	1178	1.00E-10	4.41E-07
1794-OB8EPXT	A		FLEX I/O-XT 24V DC electronically-fused output module	14,771,049	6.77E-08	3.38E-08	80%	1.35E-08	2.03E-08	1762				1.08E-07	1178	6.78E-10	2.99E-06
1794-OB16	A	Not Applicable	FLEX I/O 24V DC output module	54,322,632	1.84E-08	9.20E-09	80%	3.68E-09	5.52E-09	1762				2.95E-08	1178	1.84E-10	8.11E-07
1794-OB16P	A		FLEX I/O 24V DC protected output module	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	1762				1.60E-08	1178	1.00E-10	4.41E-07
1794-OB16PXT	A		FLEX I/O-XT 24V DC protected output module	26,709,401	3.74E-08	1.87E-08	80%	7.49E-09	1.12E-08	1762				5.99E-08	1178	3.75E-10	1.65E-06
1794-OW8	A		FLEX I/O isolated relay output module	29,088,895	3.44E-08	1.72E-08	80%	6.88E-09	1.03E-08	1762				5.50E-08	1178	3.44E-10	1.52E-06
1794-OW8XT	A		FLEX I/O-XT isolated relay output module	18,518,519	5.40E-08	2.70E-08	80%	1.08E-08	1.62E-08	1762				8.64E-08	1178	5.41E-10	2.38E-06
1794-IE8	B	Not Applicable	FLEX I/O analog input module	18,914,770	5.29E-08	2.64E-08	80%	1.06E-08	1.59E-08	1762				8.46E-08	1178	5.30E-10	2.33E-06
1794-IE8XT	B		FLEX I/O-XT analog input module	14,041,000	7.12E-08	3.56E-08	80%	1.42E-08	2.14E-08	1762				1.14E-07	1178	7.14E-10	3.14E-06
1794-IF4I	A	I	FLEX I/O isolated analog input module	9,885,959	1.01E-07	5.06E-08	80%	2.02E-08	3.03E-08	1762				1.62E-07	1178	1.01E-09	4.47E-06
1794-IF4IXT	A	I	FLEX I/O-XT isolated analog input module	7,297,140	1.37E-07	6.85E-08	80%	2.74E-08	4.11E-08	1762				2.19E-07	1178	1.38E-09	6.05E-06
1794-IF4ICFXT	A	I	FLEX I/O-XT isolated analog input module	7,297,140	1.37E-07	6.85E-08	80%	2.74E-08	4.11E-08	1762				2.19E-07	1178	1.38E-09	6.05E-06
1794-IR8	A	K	FLEX I/O RTD input module	5,016,231	1.99E-07	9.97E-08	80%	3.99E-08	5.98E-08	1762				3.19E-07	1178	2.01E-09	8.82E-06
1794-IR8XT	A	K	FLEX I/O-XT RTD input module	9,585,890	1.04E-07	5.22E-08	80%	2.09E-08	3.13E-08	1762				1.67E-07	1178	1.05E-09	4.61E-06
1794-IRT8	B	E.1	FLEX I/O RTD/Thermocouple input module	1,407,269	7.11E-07	3.55E-07	80%	1.42E-07	2.13E-07	1762				1.14E-06	1178	7.27E-09	3.18E-05
1794-IRT8XT	B	E.1	FLEX I/O-XT RTD/Thermocouple input module	8,204,792	1.22E-07	6.09E-08	80%	2.44E-08	3.66E-08	1762				1.95E-07	1178	1.22E-09	5.38E-06
1794-IT8	A	K	FLEX I/O Thermocouple input module	2,097,509	4.77E-07	2.38E-07	80%	9.54E-08	1.43E-07	1762				7.63E-07	1178	4.84E-09	2.12E-05
1794-IF2XOF2I	A	I	FLEX I/O isolated analog input/output module	8,464,844	1.18E-07	5.91E-08	80%	2.36E-08	3.54E-08	1762				1.89E-07	1178	1.19E-09	5.22E-06
1794-IF2XOF2IXT	A	I	FLEX I/O-XT isolated analog input/output module	6,317,918	1.58E-07	7.91E-08	80%	3.17E-08	4.75E-08	1762				2.53E-07	1178	1.59E-09	7.00E-06
1794-IE4XOE2XT	B	Not Applicable	FLEX I/O-XT analog input/output module	11,800,802	8.47E-08	4.24E-08	80%	1.69E-08	2.54E-08	1762				1.36E-07	1178	8.50E-10	3.74E-06
1794-OE4	B		FLEX I/O analog output module	18,433,610	5.42E-08	2.71E-08	80%	1.08E-08	1.63E-08	1762	Not allowed for 1oo1 configurations			8.68E-08	1178	5.43E-10	2.39E-06
1794-OE4XT	B		FLEX I/O-XT analog output module	11,381,744	8.79E-08	4.39E-08	80%	1.76E-08	2.64E-08	1762				1.41E-07	1178	8.81E-10	3.88E-06
1794-OF4I	A	I	FLEX I/O analog output module	23,884,409	4.19E-08	2.09E-08	80%	8.37E-09	1.26E-08	1762				6.70E-08	1178	4.19E-10	1.85E-06
1794-OF4IXT	A	I	FLEX I/O-XT analog output module	5,493,902	1.82E-07	9.10E-08	80%	3.64E-08	5.46E-08	1762				2.91E-07	1178	1.83E-09	8.05E-06

Table 10 - 1- Year PFD Calculations

Cat No.[1]	Series	Firmware Version[6]	Description	Mean Time between Failure (MTBF)[7]	Common Terms[8]						1oo1 Configuration			1oo2 Configuration			
					λ[9]	λ_s, λ_d	Safe Failure Fraction (SFF)	λ_{du}	λ_{dd}	T_{CE1oo1}	Spurious Trip Rate STR	PFH[10]	PFD	Spurious Trip Rate STR	T_{GE}	PFH[10]	PFD
1794-TB3	A	Not Applicable	FLEX I/O terminal base unit	250,000,000	4.00E-09	2.00E-09	80%	8.00E-10	1.20E-09	1762	Not allowed for 1oo1 configurations			6.40E-09	1178	4.00E-11	1.76E-07
1794-TB3G	A		FLEX I/O cage-clamp generic terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	1762				1.60E-08	1178	1.00E-10	4.41E-07
1794-TB3GS	A		FLEX I/O spring-clamp generic terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	1762				1.60E-08	1178	1.00E-10	4.41E-07
1794-TB3S	A		FLEX I/O terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	1762				1.60E-08	1178	1.00E-10	4.41E-07
1794-TB3T	A		FLEX I/O temperature terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	1762				1.60E-08	1178	1.00E-10	4.41E-07
1794-TB3TS	A		FLEX I/O spring-clamp temperature terminal base unit	52,312,000	1.91E-08	9.56E-09	80%	3.82E-09	5.73E-09	1762				3.06E-08	1178	1.91E-10	8.42E-07
1794-TBN	A		FLEX I/O NEMA terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	1762				1.60E-08	1178	1.00E-10	4.41E-07
1794-TBNF	A		FLEX I/O NEMA fused terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	1762				1.60E-08	1178	1.00E-10	4.41E-07
1492-TIFM40F-F24A-2[5]	A	Not Applicable	DC Input Termination Board	7,779,000	Non-interference only						1.03E-07	Not Applicable		7.90E-08	Not Applicable		
1492-TAIFM16-F-3[5]	A		Analog Input Termination Board	11,362,000							7.04E-08			1.03E-07			
1492-TIFM40F-24-2[5]	A		DC Output Termination Board	10,127,000							7.90E-08			7.04E-08			

(1) Some catalog numbers have a K suffix. This indicates a version of the product that has conformal coating. These K versions have the same SIL 2 certification as the non-K versions. For more information on which products have conformal coating go to http://ab.com.rockwellautomation.com/

(2) Average of 1756-A4, -A7, -A10, -A13 and -A17 chassis.

(3) Suitable for use only in applications requiring compliance to IEC 61508 1999 Edition 1.

(4) Calculated MTBF and PFD by FMEA to 61508-2010.

(5) SIL 2-rated for non-interference in the chassis. Data not required within a safety function.

(6) For the latest official approved firmware versions, consult the Revision Release List, Certificate Number 968/EZ/35.xx/xx available at http://www.rockwellautomation.com/rockwellautomation/certification/safety.page.

(7) MTBF measured in hours unless calculated (as noted). Field return values – January 2012.

(8) Calculations performed on a per module basis.

(9) λ = Failure Rate = 1/MTBF.

(10) Demand rate must be less than 10 per year.

2-Year PFD Calculations

The PFD calculations in this table are calculated for a 2-year proof test interval (17,520 hours) and are specific to ControlLogix system components.

Table 11 - 2-Year PFD Calculations

Cat No.[1]	Series	Firmware Version[6]	Description	Mean Time between Failure (MTBF)[7]	Common Terms[8]						1oo1 Configuration			1oo2 Configuration			
					λ[9]	λ_s , λ_d	Safe Failure Fraction (SFF)	λ_{du}	λ_{dd}	T_{CE1oo1}	Spurious Trip Rate STR	PFH[10]	PFD	Spurious Trip Rate STR	T_{GE}	PFH[10]	PFD
1756-AXX[2]	C	Not Applicable	ControlLogix chassis	22,652,010	4.41E-08	2.21E-08	95%	2.21E-09	1.99E-08	886	4.19E-08	2.21E-09	1.96E-05	Not Applicable			
1756-A4LXT	B		4-slot ControlLogix-XT chassis	1,069,120	9.35E-07	4.68E-07	95%	4.68E-08	4.21E-07	886	8.89E-07	4.68E-08	4.14E-04				
1756-A5XT	C		5-slot ControlLogix-XT chassis	734,420	1.36E-06	6.81E-07	95%	6.81E-08	6.13E-07	886	1.29E-06	6.81E-08	6.03E-04				
1756-A7LXT	B		7-slot ControlLogix-XT chassis	27,628,178	3.62E-08	1.81E-08	95%	1.81E-09	1.63E-08	886	3.44E-08	1.81E-09	1.60E-05				
1756-A7XT	C		7-slot ControlLogix-XT chassis	1,081,600	9.25E-07	4.62E-07	95%	4.62E-08	4.16E-07	886	8.78E-07	4.62E-08	4.10E-04				
1756-PB72	C		18-32V DC 10A ControlLogix power supply	31,561,095	3.17E-08	1.58E-08	95%	1.58E-09	1.43E-08	886	3.01E-08	1.58E-09	1.40E-05				
1756-PA72	C		85-265V AC 10A ControlLogix power supply	18,336,146	5.45E-08	2.73E-08	95%	2.73E-09	2.45E-08	886	5.18E-08	2.73E-09	2.42E-05				
1756-PA75	B		85-265V AC 13A ControlLogix power supply (75W)	18,693,044	5.35E-08	2.67E-08	95%	2.67E-09	2.41E-08	886	5.08E-08	2.67E-09	2.37E-05				
1756-PA75R	A		85-265V AC 13A Redundant ControlLogix power supply	1,412,877	7.08E-07	3.54E-07	95%	3.54E-08	3.18E-07	886	6.72E-07	3.54E-08	3.14E-04				
1756-PB75	B		18-32V DC 13A ControlLogix power supply	15,675,475	6.38E-08	3.19E-08	95%	3.19E-09	2.87E-08	886	6.06E-08	3.19E-09	2.83E-05				
1756-PB75R	A		18-32V DC 13A Redundant ControlLogix power supply	1,736,020	5.76E-07	2.88E-07	95%	2.88E-08	2.59E-07	886	5.47E-07	2.88E-08	2.55E-04				
1756-PAXT	B		ControlLogix-XT AC power supply	18,693,044	5.35E-08	2.67E-08	95%	2.67E-09	2.41E-08	886	5.08E-08	2.67E-09	2.37E-05				
1756-PBXT	B		ControlLogix-XT DC power supply	1,855,360	5.39E-07	2.69E-07	95%	2.69E-08	2.43E-07	886	5.12E-07	2.69E-08	2.39E-04				
1756-PC75	B		30-60V DC 13A ControlLogix power supply	5,894,836	1.70E-07	8.48E-08	95%	8.48E-09	7.63E-08	886	1.61E-07	8.48E-09	7.52E-05				
1756-PH75	B		90-143V DC 13A ControlLogix power supply	2,119,520	4.72E-07	2.36E-07	95%	2.36E-08	2.12E-07	886	4.48E-07	2.36E-08	2.09E-04				
1756-PSCA	A		Redundant power supply adapter	45,146,727	2.21E-08	1.11E-08	95%	1.11E-09	9.97E-09	886	2.10E-08	1.11E-09	9.81E-06				
1756-PSCA2	A		Redundant power supply adapter	38,461,280	2.60E-08	1.30E-08	95%	1.30E-09	1.17E-08	886	2.47E-08	1.30E-09	1.15E-05				
1786-RPFS	A		ControlNet Fiber repeater - short	26,461,760	3.78E-08	1.89E-08	95%	1.89E-09	1.70E-08	886	3.59E-08	1.89E-09	1.67E-05				
1786-RPFM	A		ControlNet Fiber repeater - medium	16,697,862	5.99E-08	2.99E-08	95%	2.99E-09	2.69E-08	886	5.69E-08	2.99E-09	2.65E-05				
1786-RPFRL	A		ControlNet Fiber repeater - long	5,717,227	1.75E-07	8.75E-08	95%	8.75E-09	7.87E-08	886	1.66E-07	8.75E-09	7.75E-05				
1786-RPCD	A		ControlNet Hub repeater	28,654,080	3.49E-08	1.74E-08	95%	1.74E-09	1.57E-08	886	3.32E-08	1.74E-09	1.55E-05				
1786-RPA	B		ControlNet repeater adapter	11,826,146	8.46E-08	4.23E-08	95%	4.23E-09	3.81E-08	886	8.03E-08	4.23E-09	3.75E-05				
1786-RPFRXL	B		ControlNet Fiber repeater - extra long	11,373,440	8.79E-08	4.40E-08	95%	4.40E-09	3.96E-08	886	8.35E-08	4.40E-09	3.90E-05				
1756-L61[3]	B	20.012 20.055	ControlLogix controller, 2MB	1,000,053	1.00E-06	5.00E-07	95%	5.00E-08	4.50E-07	886	9.50E-07	5.00E-08	4.43E-04	Not Applicable			
1756-L62[3]	B	20.012 20.055	ControlLogix controller, 4MB	1,034,830	9.66E-07	4.83E-07	95%	4.83E-08	4.35E-07	886	9.18E-07	4.83E-08	4.28E-04				
1756-L63[3]	B	20.012 20.055	ControlLogix controller, 8MB	1,055,910	9.47E-07	4.74E-07	95%	4.74E-08	4.26E-07	886	9.00E-07	4.74E-08	4.20E-04				
1756-L63XT[3]	B	20.012 20.055	ControlLogix-XT controller, 8MB	357,760	2.80E-06	1.40E-06	95%	1.40E-07	1.26E-06	886	2.66E-06	1.40E-07	1.24E-03				
1756-L71[4]	B	20.012 20.055	ControlLogix controller, 2MB	Calculated MTBF and PFD via FMEA	2.69E-06	1.34E-06	96%	1.01E-07	1.25E-06	670	2.91E-06	1.01E-07	8.90E-04	Not Applicable			
1756-L72[4]	B	20.012 20.055	ControlLogix controller, 4MB		2.69E-06	1.34E-06	96%	1.01E-07	1.25E-06	670	2.91E-06	1.01E-07	8.90E-04				
1756-L73[4]	B	20.012 20.055	ControlLogix controller, 8MB		2.69E-06	1.34E-06	96%	1.01E-07	1.25E-06	670	2.91E-06	1.01E-07	8.90E-04				
1756-L73XT[4]	B	20.012 20.055	ControlLogix-XT controller, 8MB		2.69E-06	1.34E-06	96%	1.01E-07	1.25E-06	670	2.91E-06	1.01E-07	8.90E-04				
1756-L74[4]	B	20.012 20.055	ControlLogix controller, 16MB		2.69E-06	1.34E-06	96%	1.01E-07	1.25E-06	670	2.91E-06	1.01E-07	8.90E-04				
1756-L75[4]	B	20.012 20.055	ControlLogix controller, 32MB		2.69E-06	1.34E-06	96%	1.01E-07	1.25E-06	670	2.91E-06	1.01E-07	8.90E-04				

Table 11 - 2-Year PFD Calculations

Cat No.[1]	Series	Firmware Version[6]	Description	Mean Time between Failure (MTBF)[7]	Common Terms[8]						1oo1 Configuration			1oo2 Configuration			
					λ[9]	λ_s , λ_d	Safe Failure Fraction (SFF)	λ_{du}	λ_{dd}	T_{CE1oo1}	Spurious Trip Rate STR	PFH[10]	PFD	Spurious Trip Rate STR	T_{GE}	PFH[10]	PFD
1756-CNB	E	11.005	ControlLogix ControlNet communication module	1,786,977	5.60E-07	2.80E-07	95%	2.80E-08	2.52E-07	886	5.32E-07	2.80E-08	2.48E-04				
1756-CNBR	E	11.005	ControlLogix ControlNet redundant communication module	2,608,543	3.83E-07	1.92E-07	95%	1.92E-08	1.73E-07	886	3.64E-07	1.92E-08	1.70E-04				
1756-CN2	B	20.011	ControlLogix ControlNet communication module	1,096,299	9.12E-07	4.56E-07	95%	4.56E-08	4.10E-07	886	8.67E-07	4.56E-08	4.04E-04				
1756-CN2	C	25.004	ControlLogix ControlNet communication module	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	597.25	1.91E-06	6.62E-08	5.90E-04				
1756-CN2R	B	20.011	ControlLogix ControlNet redundant communication module	1,096,299	9.12E-07	4.56E-07	95%	4.56E-08	4.10E-07	886	8.67E-07	4.56E-08	4.04E-04	Not Applicable			
1756-CN2R	C	25.004	ControlLogix ControlNet redundant communication module	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	597.25	1.91E-06	6.62E-08	5.90E-04				
1756-CN2RXT	B	20.011	ControlLogix-XT ControlNet redundant communication module	1,980,160	5.05E-07	2.53E-07	95%	2.53E-08	2.27E-07	886	4.80E-07	2.53E-08	2.24E-04				
1756-CN2RXT	C	25.004	ControlLogix-XT ControlNet redundant communication module	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	597.25	1.91E-06	6.62E-08	5.90E-04				
1756-DHRIO[5]	E	7.002	ControlLogix Data Highway Plus Remote I/O Module	2,503,396	Non-interference only						3.79E-07	Not applicable		7.59E-07	Not applicable		
1756-DHRIOXT[5]	E	7.002	ControlLogix-XT Data Highway Plus Remote I/O Module	2,503,396							3.79E-07			7.59E-07			
1756-DNB[5]	D	12.005	ControlLogix DeviceNet communication module	2,192,202							4.33E-07			8.67E-07			
1756-ENBT[5]	A	4.008 6.006	ControlLogix EtherNet/IP communication module	2,088,198							4.55E-07			9.10E-07			
1756-EN2T	C	5.008	ControlLogix EtherNet/IP communication module	1,312,712	7.62E-07	3.81E-07	95%	3.81E-08	3.43E-07	886	7.24E-07	3.81E-08	3.37E-04	Not Applicable			
1756-EN2T	D	10.007	ControlLogix EtherNet/IP communication module	269,774	Non-interference only						3.71E-06	Not applicable					
1756-EN2TR	B	5.008	ControlLogix EtherNet/IP communication module with fault tolerance	3,664,960	2.73E-07	1.36E-07	95%	1.36E-08	1.23E-07	886	2.59E-07	1.36E-08	1.21E-04				
1756-EN2TR	C	10.006	ControlLogix EtherNet/IP communication module with fault tolerance	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	597.25	1.91E-06	6.62E-08	5.90E-04	3.82E-06	401.50	1.40E-09	1.22E-05
1756-EN2TRXT	C	10.006	ControlLogix EtherNet/IP communication module with fault tolerance		1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	597.25	1.91E-06	6.62E-08	5.90E-04	3.82E-06	401.50	1.40E-09	1.22E-05
1756-EN2TXT	C	5.008	ControlLogix-XT EtherNet/IP communication module	1,300,000	7.69E-07	3.85E-07	95%	3.85E-08	3.46E-07	886	7.31E-07	3.85E-08	3.41E-04	Not Applicable			
1756-EN2TXT	D	10.007	ControlLogix-XT EtherNet/IP communication module	269,774	Non-interference only						3.71E-06	Not applicable					
1756-EN3TR	B	10.007	ControlLogix EtherNet/IP communication module with fault tolerance	269,774							3.71E-06						
1756-RM[5]	B	3.003	ControlLogix redundancy module	1,373,840							6.91E-07						
1756-RM2	A	20.004	ControlLogix enhanced redundancy module	250,182							4.00E-06						
1756-RM2XT	A	20.004	ControlLogix-XT enhanced redundancy module	250,182							4.00E-06						
1756-RMXT[5]	B	3.003	ControlLogix-XT redundancy module	980,096							9.69E-07						
1756-SYNCH[5]	A	2.018	ControlLogix SyncLink Module	6,932,640							1.37E-07	Not applicable		2.74E-07	Not applicable		
1756-IA16I	A	3.003	ControlLogix isolated V AC input module	20,801,920	4.81E-08	2.40E-08	80%	9.61E-09	1.44E-08	3514	3.85E-08	9.61E-09	8.45E-05	7.69E-08	2346	4.82E-10	4.23E-06
1756-IA8D	A	3.003	ControlLogix diagnostic V AC input module	15,966,080	6.26E-08	3.13E-08	80%	1.25E-08	1.88E-08	3514	5.01E-08	1.25E-08	1.10E-04	1.00E-07	2346	6.29E-10	5.52E-06
1756-IB16D	A	3.003	ControlLogix diagnostic V DC input module	30,228,640	3.31E-08	1.65E-08	80%	6.62E-09	9.92E-09	3514	2.65E-08	6.62E-09	5.81E-05	5.29E-08	2346	3.32E-10	2.91E-06
1756-IB16I	A	3.003	ControlLogix isolated V DC input module	81,443,094	1.23E-08	6.14E-09	80%	2.46E-09	3.68E-09	3514	9.82E-09	2.46E-09	2.16E-05	1.96E-08	2346	1.23E-10	1.08E-06

Table 11 - 2-Year PFD Calculations

Cat No.[1]	Series	Firmware Version[6]	Description	Mean Time between Failure (MTBF)[7]	Common Terms[8]						1oo1 Configuration			1oo2 Configuration			
					λ[9]	λ_s , λ_d	Safe Failure Fraction (SFF)	λ_{du}	λ_{dd}	T_{CE1oo1}	Spurious Trip Rate STR	PFH[10]	PFD	Spurious Trip Rate STR	T_{GE}	PFH[10]	PFD
1756-IB16ISOE	A	2.007	ControlLogix isolated V DC Sequence Of Events input module	11,537,760	8.67E-08	4.33E-08	80%	1.73E-08	2.60E-08	3514	6.93E-08	1.73E-08	1.52E-04	1.39E-07	2346	8.71E-10	7.64E-06
1756-IB32	B	3.005	ControlLogix V DC input module	10,462,329	9.56E-08	4.78E-08	80%	1.91E-08	2.87E-08	3514	7.65E-08	1.91E-08	1.68E-04	1.53E-07	2346	9.62E-10	8.43E-06
1756-IF8	A	1.005	ControlLogix analog input module	8,699,254	1.15E-07	5.75E-08	80%	2.30E-08	3.45E-08	3514	9.20E-08	2.30E-08	2.02E-04	1.84E-07	2346	1.16E-09	1.01E-05
1756-IF8H	A	1.002	ControlLogix HART analog input module	1,291,978	7.74E-07	3.87E-07	80%	1.55E-07	2.32E-07	3514	6.19E-07	1.55E-07	1.36E-03	1.24E-06	2346	8.12E-09	7.02E-05
1756-IF16	A	1.005	ControlLogix analog input module	4,592,506	2.18E-07	1.09E-07	80%	4.35E-08	6.53E-08	3514	1.74E-07	4.35E-08	3.83E-04	3.48E-07	2346	2.21E-09	1.93E-05
1756-IF16H	A	1.002	ControlLogix HART analog input module	442,914	2.26E-06	1.13E-06	80%	4.52E-07	6.77E-07	3514	1.81E-06	4.52E-07	3.97E-03	3.61E-06	2346	2.58E-08	2.17E-04
1756-IF6CIS	A	1.013	ControlLogix isolated analog input module	2,654,080	3.77E-07	1.88E-07	80%	7.54E-08	1.13E-07	3514	3.01E-07	7.54E-08	6.62E-04	6.03E-07	2346	3.86E-09	3.36E-05
1756-IF6I	A	1.013	ControlLogix isolated analog input module	4,176,185	2.39E-07	1.20E-07	80%	4.79E-08	7.18E-08	3514	1.92E-07	4.79E-08	4.21E-04	3.83E-07	2346	2.43E-09	2.12E-05
1756-IH16ISOE	A	2.007	ControlLogix V DC Sequence Of Events input module	2,150,720	4.65E-07	2.32E-07	80%	9.30E-08	1.39E-07	3514	3.72E-07	9.30E-08	8.17E-04	7.44E-07	2346	4.79E-09	4.17E-05
1756-IR6I	A	1.013	ControlLogix isolated RTD input module	4,268,525	2.34E-07	1.17E-07	80%	4.69E-08	7.03E-08	3514	Not allowed for 1oo1 configurations			3.75E-07	2346	2.38E-09	2.08E-05
1756-IT6I	A	1.013	ControlLogix isolated thermocouple input module	3,957,824	2.53E-07	1.26E-07	80%	5.05E-08	7.58E-08	3514				4.04E-07	2346	2.57E-09	2.24E-05
1756-IT6I2	A	1.013	ControlLogix isolated enhanced thermocouple input module	2,720,046	3.68E-07	1.84E-07	80%	7.35E-08	1.10E-07	3514				5.88E-07	2346	3.76E-09	3.28E-05
1756-OA16I	A	3.002	ControlLogix V AC output module	32,891,456	3.04E-08	1.52E-08	80%	6.08E-09	9.12E-09	3514	2.43E-08	6.08E-09	5.34E-05	4.86E-08	2346	3.05E-10	2.67E-06
1756-OA8D	A	3.003	ControlLogix V AC diagnostic output module	11,311,040	8.84E-08	4.42E-08	80%	1.77E-08	2.65E-08	3514	7.07E-08	1.77E-08	1.55E-04	1.41E-07	2346	8.89E-10	7.80E-06
1756-OB16D	A	3.002	ControlLogix V DC diagnostic output module	8,884,374	1.13E-07	5.63E-08	80%	2.25E-08	3.38E-08	3514	9.00E-08	2.25E-08	1.98E-04	1.80E-07	2346	1.13E-09	9.94E-06
1756-OB16E	A	3.003	ControlLogix V DC electronic ally-fused output module	14,997,714	6.67E-08	3.33E-08	80%	1.33E-08	2.00E-08	3514	5.33E-08	1.33E-08	1.17E-04	1.07E-07	2346	6.70E-10	5.87E-06
1756-OB16I	A	3.002	ControlLogix V DC isolated output module	7,388,160	1.35E-07	6.77E-08	80%	2.71E-08	4.06E-08	3514	1.08E-07	2.71E-08	2.38E-04	2.17E-07	2346	1.37E-09	1.20E-05
1756-OB32	A	3.002	ControlLogix V DC output module	2,681,316	3.73E-07	1.86E-07	80%	7.46E-08	1.12E-07	3514	2.98E-07	7.46E-08	6.55E-04	5.97E-07	2346	3.82E-09	3.33E-05
1756-OB8EI	A	3.002	ControlLogix V DC isolated electronic ally-fused output module	14,019,200	7.13E-08	3.57E-08	80%	1.43E-08	2.14E-08	3514	5.71E-08	1.43E-08	1.25E-04	1.14E-07	2346	7.17E-10	6.29E-06
1756-OX8I	A	3.002	ControlLogix isolated relay output module	6,059,635	1.65E-07	8.25E-08	80%	3.30E-08	4.95E-08	3514	1.32E-07	3.30E-08	2.90E-04	2.64E-07	2346	1.67E-09	1.46E-05
1756-OW16I	A	3.002	ControlLogix isolated relay output module	13,695,899	7.30E-08	3.65E-08	80%	1.46E-08	2.19E-08	3514	5.84E-08	1.46E-08	1.28E-04	1.17E-07	2346	7.34E-10	6.43E-06
1756-OF8	A	1.005	ControlLogix analog output module	10,629,795	9.41E-08	4.70E-08	80%	1.88E-08	2.82E-08	3514	7.53E-08	1.88E-08	1.65E-04	1.51E-07	2346	9.46E-10	8.30E-06
1756-OF6VI	A	1.013	ControlLogix isolated analog output module	21,604,960	4.63E-08	2.31E-08	80%	9.26E-09	1.39E-08	3514	3.70E-08	9.26E-09	8.13E-05	7.41E-08	2346	4.64E-10	4.07E-06
1756-OF6CI	A	1.013	ControlLogix isolated analog output module	8,354,667	1.20E-07	5.98E-08	80%	2.39E-08	3.59E-08	3514	9.58E-08	2.39E-08	2.10E-04	1.92E-07	2346	1.21E-09	1.06E-05
1756-OF8H	A	1.002	ControlLogix HART analog output module	5,118,187	1.95E-07	9.77E-08	80%	3.91E-08	5.86E-08	3514	1.56E-07	3.91E-08	3.43E-04	3.13E-07	2346	1.98E-09	1.73E-05
1794-ACN15	D	10.003	FLEX I/O ControlNet adapter	8,223,684	1.22E-07	6.08E-08	80%	2.43E-08	3.65E-08	3514	Not allowed for 1oo1 configurations			1.95E-07	2346	1.23E-09	1.07E-05
1794-ACNR15	D	10.003	FLEX I/O ControlNet redundant adapter	8,223,684	1.22E-07	6.08E-08	80%	2.43E-08	3.65E-08	3514				1.95E-07	2346	1.23E-09	1.07E-05
1794-ACNR15XT	D	10.003	FLEX I/O-XT ControlNet adapter	8,223,684	1.22E-07	6.08E-08	80%	2.43E-08	3.65E-08	3514				1.95E-07	2346	1.23E-09	1.07E-05
1794-AENT	B	4.003	FLEX I/O EtherNET/IP adapter	1,779,827	5.62E-07	2.81E-07	80%	1.12E-07	1.69E-07	3514				8.99E-07	2346	5.82E-09	5.05E-05
1794-AENTR	A	1.013	FLEX I/O EtherNET/IP adapter, Ring media	1,268,070	7.89E-07	3.94E-07	80%	1.58E-07	2.37E-07	3514				1.26E-06	2346	8.28E-09	7.16E-05
1794-AENTRXT	A	1.013	FLEX I/O EtherNET/IP adapter, Ring media	1,268,070	7.89E-07	3.94E-07	80%	1.58E-07	2.37E-07	3514				1.26E-06	2346	8.28E-09	7.16E-05

Table 11 - 2-Year PFD Calculations

Cat No.[1]	Series	Firmware Version[6]	Description	Mean Time between Failure (MTBF)[7]	Common Terms[8]						1oo1 Configuration			1oo2 Configuration			
					λ[9]	λ_s , λ_d	Safe Failure Fraction (SFF)	λ_{du}	λ_{dd}	T_{CE1oo1}	Spurious Trip Rate STR	PFH[10]	PFD	Spurious Trip Rate STR	T_{GE}	PFH[10]	PFD
1794-IB16	A	Not Applicable	FLEX I/O 24V DC input module	179,506,158	5.57E-09	2.79E-09	80%	1.11E-09	1.67E-09	3514	Not allowed for 1oo1 configurations			8.91E-09	2346	5.57E-11	4.90E-07
1794-IB16XT	A		FLEX I/O-XT 24V DC input module	35,587,189	2.81E-08	1.40E-08	80%	5.62E-09	8.43E-09	3514				4.50E-08	2346	2.82E-10	2.47E-06
1794-IJ2	A	D	FLEX I/O counter module	55,344,640	1.81E-08	9.03E-09	80%	3.61E-09	5.42E-09	3514				2.89E-08	2346	1.81E-10	1.59E-06
1794-IJ2XT	A	E	FLEX I/O-XT counter module	11,714,128	8.54E-08	4.27E-08	80%	1.71E-08	2.56E-08	3514				1.37E-07	2346	8.58E-10	7.53E-06
1794-IP4	B	4	FLEX I/O counter module	22,027,200	4.54E-08	2.27E-08	80%	9.08E-09	1.36E-08	3514				7.26E-08	2346	4.55E-10	4.00E-06
1794-IB10XOB6	A	Not Applicable	FLEX I/O 24V DC input/output module	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	3514				1.60E-08	2346	1.00E-10	8.79E-07
1794-IB10XOB6XT	A		FLEX I/O-XT 24V DC input/output module	22,202,487	4.50E-08	2.25E-08	80%	9.01E-09	1.35E-08	3514				7.21E-08	2346	4.52E-10	3.96E-06
1794-OB8EP	A		FLEX I/O 24V DC electronically-fused output module	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	3514	Not allowed for 1oo1 configurations			1.60E-08	2346	1.00E-10	8.79E-07
1794-OB8EPXT	A		FLEX I/O-XT 24V DC electronically-fused output module	14,771,049	6.77E-08	3.38E-08	80%	1.35E-08	2.03E-08	3514				1.08E-07	2346	6.80E-10	5.96E-06
1794-OB16	A	Not Applicable	FLEX I/O 24V DC output module	54,322,632	1.84E-08	9.20E-09	80%	3.68E-09	5.52E-09	3514				2.95E-08	2346	1.84E-10	1.62E-06
1794-OB16P	A		FLEX I/O 24V DC protected output module	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	3514				1.60E-08	2346	1.00E-10	8.79E-07
1794-OB16PXT	A		FLEX I/O-XT 24V DC protected output module	26,709,401	3.74E-08	1.87E-08	80%	7.49E-09	1.12E-08	3514				5.99E-08	2346	3.75E-10	3.29E-06
1794-OW8	A		FLEX I/O isolated relay output module	29,088,895	3.44E-08	1.72E-08	80%	6.88E-09	1.03E-08	3514				5.50E-08	2346	3.45E-10	3.02E-06
1794-OW8XT	A		FLEX I/O-XT isolated relay output module	18,518,519	5.40E-08	2.70E-08	80%	1.08E-08	1.62E-08	3514				8.64E-08	2346	5.42E-10	4.75E-06
1794-IE8	B	Not Applicable	FLEX I/O analog input module	18,914,770	5.29E-08	2.64E-08	80%	1.06E-08	1.59E-08	3514	Not allowed for 1oo1 configurations			8.46E-08	2346	5.30E-10	4.65E-06
1794-IE8XT	B		FLEX I/O-XT analog input module	14,041,000	7.12E-08	3.56E-08	80%	1.42E-08	2.14E-08	3514				1.14E-07	2346	7.15E-10	6.28E-06
1794-IF4I	A	I	FLEX I/O isolated analog input module	9,885,959	1.01E-07	5.06E-08	80%	2.02E-08	3.03E-08	3514				1.62E-07	2346	1.02E-09	8.92E-06
1794-IF4IXT	A	I	FLEX I/O-XT isolated analog input module	7,297,140	1.37E-07	6.85E-08	80%	2.74E-08	4.11E-08	3514				2.19E-07	2346	1.38E-09	1.21E-05
1794-IF4ICFXT	A	I	FLEX I/O-XT isolated analog input module	7,297,140	1.37E-07	6.85E-08	80%	2.74E-08	4.11E-08	3514				2.19E-07	2346	1.38E-09	1.21E-05
1794-IR8	A	K	FLEX I/O RTD input module	5,016,231	1.99E-07	9.97E-08	80%	3.99E-08	5.98E-08	3514				3.19E-07	2346	2.02E-09	1.77E-05
1794-IR8XT	A	K	FLEX I/O-XT RTD input module	9,585,890	1.04E-07	5.22E-08	80%	2.09E-08	3.13E-08	3514				1.67E-07	2346	1.05E-09	9.20E-06
1794-IRT8	B	E.1	FLEX I/O RTD/Thermocouple input module	1,407,269	7.11E-07	3.55E-07	80%	1.42E-07	2.13E-07	3514				1.14E-06	2346	7.43E-09	6.43E-05
1794-IRT8XT	B	E.1	FLEX I/O-XT RTD/Thermocouple input module	8,204,792	1.22E-07	6.09E-08	80%	2.44E-08	3.66E-08	3514				1.95E-07	2346	1.23E-09	1.08E-05
1794-IT8	A	K	FLEX I/O Thermocouple input module	2,097,509	4.77E-07	2.38E-07	80%	9.54E-08	1.43E-07	3514				7.63E-07	2346	4.91E-09	4.27E-05
1794-IF2XOF2I	A	I	FLEX I/O isolated analog input/output module	8,464,844	1.18E-07	5.91E-08	80%	2.36E-08	3.54E-08	3514				1.89E-07	2346	1.19E-09	1.04E-05
1794-IF2XOF2IXT	A	I	FLEX I/O-XT isolated analog input/output module	6,317,918	1.58E-07	7.91E-08	80%	3.17E-08	4.75E-08	3514				2.53E-07	2346	1.60E-09	1.40E-05
1794-IE4XOE2XT	B	Not Applicable	FLEX I/O-XT analog input/output module	11,800,802	8.47E-08	4.24E-08	80%	1.69E-08	2.54E-08	3514				1.36E-07	2346	8.52E-10	7.47E-06
1794-OE4	B		FLEX I/O analog output module	18,433,610	5.42E-08	2.71E-08	80%	1.08E-08	1.63E-08	3514	Not allowed for 1oo1 configurations			8.68E-08	2346	5.44E-10	4.78E-06
1794-OE4XT	B		FLEX I/O-XT analog output module	11,381,744	8.79E-08	4.39E-08	80%	1.76E-08	2.64E-08	3514				1.41E-07	2346	8.83E-10	7.75E-06
1794-OF4I	A	I	FLEX I/O analog output module	23,884,409	4.19E-08	2.09E-08	80%	8.37E-09	1.26E-08	3514				6.70E-08	2346	4.20E-10	3.68E-06
1794-OF4IXT	A	I	FLEX I/O-XT analog output module	5,493,902	1.82E-07	9.10E-08	80%	3.64E-08	5.46E-08	3514				2.91E-07	2346	1.84E-09	1.61E-05

Table 11 - 2-Year PFD Calculations

Cat No.[1]	Series	Firmware Version[6]	Description	Mean Time between Failure (MTBF)[7]	Common Terms[8]						1oo1 Configuration			1oo2 Configuration			
					λ[9]	λ_s , λ_d	Safe Failure Fraction (SFF)	λ_{du}	λ_{dd}	T_{CE1oo1}	Spurious Trip Rate STR	PFH[10]	PFD	Spurious Trip Rate STR	T_{GE}	PFH[10]	PFD
1794-TB3	A	Not Applicable	FLEX I/O terminal base unit	250,000,000	4.00E-09	2.00E-09	80%	8.00E-10	1.20E-09	3514	Not allowed for 1oo1 configurations			6.40E-09	2346	4.00E-11	3.51E-07
1794-TB3G	A		FLEX I/O cage-clamp generic terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	3514				1.60E-08	2346	1.00E-10	8.79E-07
1794-TB3GS	A		FLEX I/O spring-clamp generic terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	3514				1.60E-08	2346	1.00E-10	8.79E-07
1794-TB3S	A		FLEX I/O terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	3514				1.60E-08	2346	1.00E-10	8.79E-07
1794-TB3T	A		FLEX I/O temperature terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	3514				1.60E-08	2346	1.00E-10	8.79E-07
1794-TB3TS	A		FLEX I/O spring-clamp temperature terminal base unit	52,312,000	1.91E-08	9.56E-09	80%	3.82E-09	5.73E-09	3514				3.06E-08	2346	1.91E-10	1.68E-06
1794-TBN	A		FLEX I/O NEMA terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	3514				1.60E-08	2346	1.00E-10	8.79E-07
1794-TBNF	A		FLEX I/O NEMA fused terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	3514				1.60E-08	2346	1.00E-10	8.79E-07
1492-TIFM40F-F24A-2[5]	A	Not Applicable	DC Input Termination Board	7,779,000	Non-interference only						1.03E-07	Not Applicable		1.03E-07	Not Applicable		
1492-TAIFM16-F-3[5]	A		Analog Input Termination Board	11,362,000							7.04E-08			7.04E-08			
1492-TIFM40F-24-2[5]	A		DC Output Termination Board	10,127,000							7.90E-08			7.90E-08			

(1) Some catalog numbers have a K suffix. This indicates a version of the product that has conformal coating. These K versions have the same SIL 2 certification as the non-K versions. For more information on which products have conformal coating go to http://ab.com.rockwellautomation.com/

(2) Average of 1756-A4, -A7, -A10, -A13 and -A17 chassis.

(3) Suitable for use only in applications requiring compliance to IEC 61508 1999 Edition 1

(4) Calculated MTBF and PFD by FMEA to 61508-2010.

(5) SIL 2-rated for non-interference in the chassis. Data not required within a safety function.

(6) For the latest official approved firmware versions, consult the Revision Release List, Certificate Number 968/EZ/35.xx/xx available at http://www.rockwellautomation.com/rockwellautomation/certification/safety.page.

(7) MTBF measured in hours unless calculated (as noted). Field return values – January 2012.

(8) Calculations performed on a per module basis.

(9) λ = Failure Rate = 1/MTBF.

(10) Demand rate must be less than 10 per year

5-year PFD Calculations

The PFD calculations in this table are calculated for a 5-year proof test interval (43,800 hours) and are specific to ControlLogix system components.

Table 12 - 5-Year PFD Calculations

Cat No.[1]	Series	Firmware Version[6]	Description	Mean Time between Failure (MTBF)[7]	Common Terms[8]						1oo1 Configuration			1oo2 Configuration			
					λ[9]	λ_s, λ_d	Safe Failure Fraction (SFF)	λ_{du}	λ_{dd}	T_{CE1oo1}	Spurious Trip Rate STR	PFH[10]	PFD	Spurious Trip Rate STR	T_{GE}	PFH[10]	PFD
1756-AXX[2]	C	Not Applicable	ControlLogix chassis	22,652,010	4.41E-08	2.21E-08	95%	2.21E-09	1.99E-08	2200	4.19E-08	2.21E-09	4.86E-05	Not Applicable			
1756-A4LXT	B		4-slot ControlLogix-XT chassis	1,069,120	9.35E-07	4.68E-07	95%	4.68E-08	4.21E-07	2200	8.89E-07	4.68E-08	1.03E-03				
1756-A5XT	C		5-slot ControlLogix-XT chassis	734,420	1.36E-06	6.81E-07	95%	6.81E-08	6.13E-07	2200	1.29E-06	6.81E-08	1.50E-03				
1756-A7LXT	B		7-slot ControlLogix-XT chassis	27,628,178	3.62E-08	1.81E-08	95%	1.81E-09	1.63E-08	2200	3.44E-08	1.81E-09	3.98E-05				
1756-A7XT	C		7-slot ControlLogix-XT chassis	1,081,600	9.25E-07	4.62E-07	95%	4.62E-08	4.16E-07	2200	8.78E-07	4.62E-08	1.02E-03				
1756-PB72	C		18-32V DC 10A ControlLogix power supply	31,561,095	3.17E-08	1.58E-08	95%	1.58E-09	1.43E-08	2200	3.01E-08	1.58E-09	3.49E-05				
1756-PA72	C		85-265V AC 10A ControlLogix power supply	18,336,146	5.45E-08	2.73E-08	95%	2.73E-09	2.45E-08	2200	5.18E-08	2.73E-09	6.00E-05				
1756-PA75	B		85-265V AC 13A ControlLogix power supply (75W)	18,693,044	5.35E-08	2.67E-08	95%	2.67E-09	2.41E-08	2200	5.08E-08	2.67E-09	5.88E-05				
1756-PA75R	A		85-265V AC 13A Redundant ControlLogix power supply	1,412,877	7.08E-07	3.54E-07	95%	3.54E-08	3.18E-07	2200	6.72E-07	3.54E-08	7.79E-04				
1756-PB75	B		18-32V DC 13A ControlLogix power supply	15,675,475	6.38E-08	3.19E-08	95%	3.19E-09	2.87E-08	2200	6.06E-08	3.19E-09	7.02E-05				
1756-PB75R	A		18-32V DC 13A Redundant ControlLogix power supply	1,736,020	5.76E-07	2.88E-07	95%	2.88E-08	2.59E-07	2200	5.47E-07	2.88E-08	6.34E-04				
1756-PAXT	B		ControlLogix-XT AC power supply	18,693,044	5.35E-08	2.67E-08	95%	2.67E-09	2.41E-08	2200	5.08E-08	2.67E-09	5.88E-05				
1756-PBXT	B		ControlLogix-XT DC power supply	1,855,360	5.39E-07	2.69E-07	95%	2.69E-08	2.43E-07	2200	5.12E-07	2.69E-08	5.93E-04				
1756-PC75	B		30-60V DC 13A ControlLogix power supply	5,894,836	1.70E-07	8.48E-08	95%	8.48E-09	7.63E-08	2200	1.61E-07	8.48E-09	1.87E-04				
1756-PH75	B		90-143V DC 13A ControlLogix power supply	2,119,520	4.72E-07	2.36E-07	95%	2.36E-08	2.12E-07	2200	4.48E-07	2.36E-08	5.19E-04				
1756-PSCA	A		Redundant power supply adapter	45,146,727	2.21E-08	1.11E-08	95%	1.11E-09	9.97E-09	2200	2.10E-08	1.11E-09	2.44E-05				
1756-PSCA2	A		Redundant power supply adapter	38,461,280	2.60E-08	1.30E-08	95%	1.30E-09	1.17E-08	2200	2.47E-08	1.30E-09	2.86E-05				
1786-RPFS	A		ControlNet Fiber repeater - short	26,461,760	3.78E-08	1.89E-08	95%	1.89E-09	1.70E-08	2200	3.59E-08	1.89E-09	4.16E-05				
1786-RPFM	A		ControlNet Fiber repeater - medium	16,697,862	5.99E-08	2.99E-08	95%	2.99E-09	2.69E-08	2200	5.69E-08	2.99E-09	6.59E-05				
1786-RPFRL	A		ControlNet Fiber repeater - long	5,717,227	1.75E-07	8.75E-08	95%	8.75E-09	7.87E-08	2200	1.66E-07	8.75E-09	1.92E-04				
1786-RPCD	A		ControlNet Hub repeater	28,654,080	3.49E-08	1.74E-08	95%	1.74E-09	1.57E-08	2200	3.32E-08	1.74E-09	3.84E-05				
1786-RPA	B		ControlNet repeater adapter	11,826,146	8.46E-08	4.23E-08	95%	4.23E-09	3.81E-08	2200	8.03E-08	4.23E-09	9.30E-05				
1786-RPFRXL	B		ControlNet Fiber repeater - extra long	11,373,440	8.79E-08	4.40E-08	95%	4.40E-09	3.96E-08	2200	8.35E-08	4.40E-09	9.67E-05				
1756-L61[3]	B	20.012 20.055	ControlLogix controller, 2MB	1,000,053	1.00E-06	5.00E-07	95%	5.00E-08	4.50E-07	2200	9.50E-07	5.00E-08	1.10E-03	Not Applicable			
1756-L62[3]	B	20.012 20.055	ControlLogix controller, 4MB	1,034,830	9.66E-07	4.83E-07	95%	4.83E-08	4.35E-07	2200	9.18E-07	4.83E-08	1.06E-03				
1756-L63[3]	B	20.012 20.055	ControlLogix controller, 8MB	1,055,910	9.47E-07	4.74E-07	95%	4.74E-08	4.26E-07	2200	9.00E-07	4.74E-08	1.04E-03				
1756-L63XT[3]	B	20.012 20.055	ControlLogix-XT controller, 8MB	357,760	2.80E-06	1.40E-06	95%	1.40E-07	1.26E-06	2200	2.66E-06	1.40E-07	3.07E-03				
1756-L71[4]	B	20.012 20.055	ControlLogix controller, 2MB	Calculated MTBF and PFD via FMEA	2.69E-06	1.34E-06	96%	1.01E-07	1.25E-06	1661	2.91E-06	1.01E-07	2.20E-03	Not Applicable			
1756-L72[4]	B	20.012 20.055	ControlLogix controller, 4MB		2.69E-06	1.34E-06	96%	1.01E-07	1.25E-06	1661	2.91E-06	1.01E-07	2.20E-03				
1756-L73[4]	B	20.012 20.055	ControlLogix controller, 8MB		2.69E-06	1.34E-06	96%	1.01E-07	1.25E-06	1661	2.91E-06	1.01E-07	2.20E-03				
1756-L73XT[4]	B	20.012 20.055	ControlLogix-XT controller, 8MB		2.69E-06	1.34E-06	96%	1.01E-07	1.25E-06	1661	2.91E-06	1.01E-07	2.20E-03				
1756-L74[4]	B	20.012 20.055	ControlLogix controller, 16MB		2.69E-06	1.34E-06	96%	1.01E-07	1.25E-06	1661	2.91E-06	1.01E-07	2.20E-03				
1756-L75[4]	B	20.012 20.055	ControlLogix controller, 32MB		2.69E-06	1.34E-06	96%	1.01E-07	1.25E-06	1661	2.91E-06	1.01E-07	2.20E-03				

Table 12 - 5-Year PFD Calculations

Cat No.[1]	Series	Firmware Version[6]	Description	Mean Time between Failure (MTBF)[7]	Common Terms[8]						1oo1 Configuration			1oo2 Configuration			
					λ[9]	λ_s, λ_d	Safe Failure Fraction (SFF)	λ_{du}	λ_{dd}	T_{CE1oo1}	Spurious Trip Rate STR	PFH[10]	PFD	Spurious Trip Rate STR	T_{GE}	PFH[10]	PFD
1756-CNB	E	11.005	ControlLogix ControlNet communication module	1,786,977	5.60E-07	2.80E-07	95%	2.80E-08	2.52E-07	2200	5.32E-07	2.80E-08	6.16E-04				
1756-CNBR	E	11.005	ControlLogix ControlNet redundant communication module	2,608,543	3.83E-07	1.92E-07	95%	1.92E-08	1.73E-07	2200	3.64E-07	1.92E-08	4.22E-04				
1756-CN2	B	20.011	ControlLogix ControlNet communication module	1,096,299	9.12E-07	4.56E-07	95%	4.56E-08	4.10E-07	2200	8.67E-07	4.56E-08	1.00E-03				
1756-CN2	C	25.004	ControlLogix ControlNet communication module	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	1478.14	1.91E-06	6.62E-08	1.50E-03				
1756-CN2R	B	20.011	ControlLogix ControlNet redundant communication module	1,096,299	9.12E-07	4.56E-07	95%	4.56E-08	4.10E-07	2200	8.67E-07	4.56E-08	1.00E-03	Not Applicable			
1756-CN2R	C	25.004	ControlLogix ControlNet redundant communication module	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	1478.14	1.91E-06	6.62E-08	1.50E-03				
1756-CN2RXT	B	20.011	ControlLogix-XT ControlNet redundant communication module	1,980,160	5.05E-07	2.53E-07	95%	2.53E-08	2.27E-07	2200	4.80E-07	2.53E-08	5.56E-04				
1756-CN2RXT	C	25.004	ControlLogix-XT ControlNet redundant communication module	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	1478.14	1.91E-06	6.62E-08	1.50E-03				
1756-DHRIO[5]	E	7.002	ControlLogix Data Highway Plus Remote I/O Module	2,503,396	Non-interference only						3.79E-07	2.00E-08	Not applicable	7.59E-07	Not applicable		
1756-DHRIOXT[5]	E	7.002	ControlLogix-XT Data Highway Plus Remote I/O Module	2,503,396							3.79E-07	2.00E-08		7.59E-07			
1756-DNB[5]	D	12.005	ControlLogix DeviceNet communication module	2,192,202							4.33E-07	2.28E-08		8.67E-07			
1756-ENBT[5]	A	4.008 6.006	ControlLogix EtherNet/IP communication module	2,088,198							4.55E-07	2.39E-08		9.10E-07			
1756-EN2T	C	5.008	ControlLogix EtherNet/IP communication module	1,312,712	7.62E-07	3.81E-07	95%	3.81E-08	3.43E-07	2200	7.24E-07	3.81E-08	8.38E-04				
1756-EN2T	D	10.007	ControlLogix EtherNet/IP communication module	269,774	Non-interference only						3.71E-06	Not applicable		Not Applicable			
1756-EN2TR	B	5.008	ControlLogix EtherNet/IP communication module with fault tolerance	3,664,960	2.73E-07	1.36E-07	95%	1.36E-08	1.23E-07	2200	2.59E-07	1.36E-08	3.00E-04				
1756-EN2TR	C	10.006	ControlLogix EtherNet/IP communication module with fault tolerance	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	1478.14	1.91E-06	6.62E-08	1.50E-03	3.82E-06	988.76	1.51E-09	3.19E-05
1756-EN2TRXT	C	10.006	ControlLogix EtherNet/IP communication module with fault tolerance		1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	1478.14	1.91E-06	6.62E-08	1.50E-03	3.82E-06	988.76	1.51E-09	3.19E-05
1756-EN2TXT	C	5.008	ControlLogix-XT EtherNet/IP communication module	1,300,000	7.69E-07	3.85E-07	95%	3.85E-08	3.46E-07	2200	7.31E-07	3.85E-08	8.46E-04	Not Applicable			
1756-EN2TXT	D	10.007	ControlLogix-XT EtherNet/IP communication module	269,774	Non-interference only						3.71E-06	Not applicable					
1756-EN3TR	B	10.007	ControlLogix EtherNet/IP communication module with fault tolerance	269,774							3.71E-06						
1756-RM[5]	B	3.003	ControlLogix redundancy module	1,373,840							6.91E-07						
1756-RM2	A	20.004	ControlLogix enhanced redundancy module	250,182							4.00E-06						
1756-RM2XT	A	20.004	ControlLogix-XT enhanced redundancy module	250,182							4.00E-06						
1756-RMXT[5]	B	3.003	ControlLogix-XT redundancy module	980,096							9.69E-07						
1756-SYNCH[5]	A	2.018	ControlLogix SyncLink Module	6,932,640							1.37E-07	Not applicable		2.74E-07	Not applicable		
1756-IA16I	A	3.003	ControlLogix isolated V AC input module	20,801,920	4.81E-08	2.40E-08	80%	9.61E-09	1.44E-08	8770	3.85E-08	9.61E-09	2.11E-04	7.69E-08	5850	4.84E-10	1.06E-05
1756-IA8D	A	3.003	ControlLogix diagnostic V AC input module	15,966,080	6.26E-08	3.13E-08	80%	1.25E-08	1.88E-08	8770	5.01E-08	1.25E-08	2.75E-04	1.00E-07	5850	6.33E-10	1.38E-05
1756-IB16D	A	3.003	ControlLogix diagnostic V DC input module	30,228,640	3.31E-08	1.65E-08	80%	6.62E-09	9.92E-09	8770	2.65E-08	6.62E-09	1.45E-04	5.29E-08	5850	3.33E-10	7.28E-06
1756-IB16I	A	3.003	ControlLogix isolated V DC input module	81,443,094	1.23E-08	6.14E-09	80%	2.46E-09	3.68E-09	8770	9.82E-09	2.46E-09	5.38E-05	1.96E-08	5850	1.23E-10	2.70E-06

Table 12 - 5-Year PFD Calculations

Cat No.[1]	Series	Firmware Version[6]	Description	Mean Time between Failure (MTBF)[7]	Common Terms[8]						1oo1 Configuration			1oo2 Configuration			
					λ[9]	λ_s , λ_d	Safe Failure Fraction (SFF)	λ_{du}	λ_{dd}	T_{CE1oo1}	Spurious Trip Rate STR	PFH[10]	PFD	Spurious Trip Rate STR	T_{GE}	PFH[10]	PFD
1756-IB16ISOE	A	2.007	ControlLogix isolated V DC Sequence Of Events input module	11,537,760	8.67E-08	4.33E-08	80%	1.73E-08	2.60E-08	8770	6.93E-08	1.73E-08	3.80E-04	1.39E-07	5850	8.79E-10	1.92E-05
1756-IB32	B	3.005	ControlLogix V DC input module	10,462,329	9.56E-08	4.78E-08	80%	1.91E-08	2.87E-08	8770	7.65E-08	1.91E-08	4.19E-04	1.53E-07	5850	9.70E-10	2.12E-05
1756-IF8	A	1.005	ControlLogix analog input module	8,699,254	1.15E-07	5.75E-08	80%	2.30E-08	3.45E-08	8770	9.20E-08	2.30E-08	5.04E-04	1.84E-07	5850	1.17E-09	2.55E-05
1756-IF8H	A	1.002	ControlLogix HART analog input module	1,291,978	7.74E-07	3.87E-07	80%	1.55E-07	2.32E-07	8770	6.19E-07	1.55E-07	3.39E-03	1.24E-06	5850	8.69E-09	1.84E-04
1756-IF16	A	1.005	ControlLogix analog input module	4,592,506	2.18E-07	1.09E-07	80%	4.35E-08	6.53E-08	8770	1.74E-07	4.35E-08	9.55E-04	3.48E-07	5850	2.25E-09	4.88E-05
1756-IF16H	A	1.002	ControlLogix HART analog input module	442,914	2.26E-06	1.13E-06	80%	4.52E-07	6.77E-07	8770	1.81E-06	4.52E-07	9.90E-03	3.61E-06	5850	3.06E-08	6.13E-04
1756-IF6CIS	A	1.013	ControlLogix isolated analog input module	2,654,080	3.77E-07	1.88E-07	80%	7.54E-08	1.13E-07	8770	3.01E-07	7.54E-08	1.65E-03	6.03E-07	5850	3.99E-09	8.59E-05
1756-IF6I	A	1.013	ControlLogix isolated analog input module	4,176,185	2.39E-07	1.20E-07	80%	4.79E-08	7.18E-08	8770	1.92E-07	4.79E-08	1.05E-03	3.83E-07	5850	2.49E-09	5.38E-05
1756-IH16ISOE	A	2.007	ControlLogix V DC Sequence Of Events input module	2,150,720	4.65E-07	2.32E-07	80%	9.30E-08	1.39E-07	8770	3.72E-07	9.30E-08	2.04E-03	7.44E-07	5850	4.99E-09	1.07E-04
1756-IR6I	A	1.013	ControlLogix isolated RTD input module	4,268,525	2.34E-07	1.17E-07	80%	4.69E-08	7.03E-08	8770	Not allowed for 1oo1 configurations			3.75E-07	5850	2.43E-09	5.26E-05
1756-IT6I	A	1.013	ControlLogix isolated thermocouple input module	3,957,824	2.53E-07	1.26E-07	80%	5.05E-08	7.58E-08	8770				4.04E-07	5850	2.63E-09	5.69E-05
1756-IT6I2	A	1.013	ControlLogix isolated enhanced thermocouple input module	2,720,046	3.68E-07	1.84E-07	80%	7.35E-08	1.10E-07	8770				5.88E-07	5850	3.89E-09	8.37E-05
1756-OA16I	A	3.002	ControlLogix V AC output module	32,891,456	3.04E-08	1.52E-08	80%	6.08E-09	9.12E-09	8770	2.43E-08	6.08E-09	1.33E-04	4.86E-08	5850	3.05E-10	6.69E-06
1756-OA8D	A	3.003	ControlLogix V AC diagnostic output module	11,311,040	8.84E-08	4.42E-08	80%	1.77E-08	2.65E-08	8770	7.07E-08	1.77E-08	3.88E-04	1.41E-07	5850	8.96E-10	1.96E-05
1756-OB16D	A	3.002	ControlLogix V DC diagnostic output module	8,884,374	1.13E-07	5.63E-08	80%	2.25E-08	3.38E-08	8770	9.00E-08	2.25E-08	4.94E-04	1.80E-07	5850	1.15E-09	2.50E-05
1756-OB16E	A	3.003	ControlLogix V DC electronic ally-fused output module	14,997,714	6.67E-08	3.33E-08	80%	1.33E-08	2.00E-08	8770	5.33E-08	1.33E-08	2.92E-04	1.07E-07	5850	6.74E-10	1.47E-05
1756-OB16I	A	3.002	ControlLogix V DC isolated output module	7,388,160	1.35E-07	6.77E-08	80%	2.71E-08	4.06E-08	8770	1.08E-07	2.71E-08	5.94E-04	2.17E-07	5850	1.38E-09	3.01E-05
1756-OB32	A	3.002	ControlLogix V DC output module	2,681,316	3.73E-07	1.86E-07	80%	7.46E-08	1.12E-07	8770	2.98E-07	7.46E-08	1.64E-03	5.97E-07	5850	3.95E-09	8.50E-05
1756-OB8EI	A	3.002	ControlLogix V DC isolated electronic ally-fused output module	14,019,200	7.13E-08	3.57E-08	80%	1.43E-08	2.14E-08	8770	5.71E-08	1.43E-08	3.13E-04	1.14E-07	5850	7.21E-10	1.58E-05
1756-OX8I	A	3.002	ControlLogix isolated relay output module	6,059,635	1.65E-07	8.25E-08	80%	3.30E-08	4.95E-08	8770	1.32E-07	3.30E-08	7.24E-04	2.64E-07	5850	1.69E-09	3.68E-05
1756-OW16I	A	3.002	ControlLogix isolated relay output module	13,695,899	7.30E-08	3.65E-08	80%	1.46E-08	2.19E-08	8770	5.84E-08	1.46E-08	3.20E-04	1.17E-07	5850	7.39E-10	1.61E-05
1756-OF8	A	1.005	ControlLogix analog output module	10,629,795	9.41E-08	4.70E-08	80%	1.88E-08	2.82E-08	8770	7.53E-08	1.88E-08	4.13E-04	1.51E-07	5850	9.55E-10	2.08E-05
1756-OF6VI	A	1.013	ControlLogix isolated analog output module	21,604,960	4.63E-08	2.31E-08	80%	9.26E-09	1.39E-08	8770	3.70E-08	9.26E-09	2.03E-04	7.41E-08	5850	4.66E-10	1.02E-05
1756-OF6CI	A	1.013	ControlLogix isolated analog output module	8,354,667	1.20E-07	5.98E-08	80%	2.39E-08	3.59E-08	8770	9.58E-08	2.39E-08	5.25E-04	1.92E-07	5850	1.22E-09	2.66E-05
1756-OF8H	A	1.002	ControlLogix HART analog output module	5,118,187	1.95E-07	9.77E-08	80%	3.91E-08	5.86E-08	8770	1.56E-07	3.91E-08	8.57E-04	3.13E-07	5850	2.01E-09	4.37E-05
1794-ACN15	D	10.003	FLEX I/O ControlNet adapter	8,223,684	1.22E-07	6.08E-08	80%	2.43E-08	3.65E-08	8770	Not allowed for 1oo1 configurations			1.95E-07	5850	1.24E-09	2.70E-05
1794-ACNR15	D	10.003	FLEX I/O ControlNet redundant adapter	8,223,684	1.22E-07	6.08E-08	80%	2.43E-08	3.65E-08	8770				1.95E-07	5850	1.24E-09	2.70E-05
1794-ACNR15XT	D	10.003	FLEX I/O-XT ControlNet adapter	8,223,684	1.22E-07	6.08E-08	80%	2.43E-08	3.65E-08	8770				1.95E-07	5850	1.24E-09	2.70E-05
1794-AENT	B	4.003	FLEX I/O EtherNET/IP adapter	1,779,827	5.62E-07	2.81E-07	80%	1.12E-07	1.69E-07	8770				8.99E-07	5850	6.12E-09	1.30E-04
1794-AENTR	A	1.013	FLEX I/O EtherNET/IP adapter, Ring media	1,268,070	7.89E-07	3.94E-07	80%	1.58E-07	2.37E-07	8770				1.26E-06	5850	8.87E-09	1.87E-04
1794-AENTRXT	A	1.013	FLEX I/O EtherNET/IP adapter, Ring media	1,268,070	7.89E-07	3.94E-07	80%	1.58E-07	2.37E-07	8770				1.26E-06	5850	8.87E-09	1.87E-04

Table 12 - 5-Year PFD Calculations

Cat No.[1]	Series	Firmware Version[6]	Description	Mean Time between Failure (MTBF)[7]	Common Terms[8]						1oo1 Configuration			1oo2 Configuration			
					λ[9]	λ_s, λ_d	Safe Failure Fraction (SFF)	λ_{du}	λ_{dd}	T_{CE1oo1}	Spurious Trip Rate STR	PFH[10]	PFD	Spurious Trip Rate STR	T_{GE}	PFH[10]	PFD
1794-IB16	A	Not Applicable	FLEX I/O 24V DC input module	179,506,158	5.57E-09	2.79E-09	80%	1.11E-09	1.67E-09	8770	Not allowed for 1oo1 configurations			8.91E-09	5850	5.58E-11	1.22E-06
1794-IB16XT	A		FLEX I/O-XT 24V DC input module	35,587,189	2.81E-08	1.40E-08	80%	5.62E-09	8.43E-09	8770				4.50E-08	5850	2.82E-10	6.18E-06
1794-IJ2	A	D	FLEX I/O counter module	55,344,640	1.81E-08	9.03E-09	80%	3.61E-09	5.42E-09	8770				2.89E-08	5850	1.81E-10	3.97E-06
1794-IJ2XT	A	E	FLEX I/O-XT counter module	11,714,128	8.54E-08	4.27E-08	80%	1.71E-08	2.56E-08	8770				1.37E-07	5850	8.65E-10	1.89E-05
1794-IP4	B	4	FLEX I/O counter module	22,027,200	4.54E-08	2.27E-08	80%	9.08E-09	1.36E-08	8770				7.26E-08	5850	4.57E-10	1.00E-05
1794-IB10XOB6	A	Not Applicable	FLEX I/O 24V DC input/output module	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	8770				1.60E-08	5850	1.00E-10	2.19E-06
1794-IB10XOB6XT	A		FLEX I/O-XT 24V DC input/output module	22,202,487	4.50E-08	2.25E-08	80%	9.01E-09	1.35E-08	8770				7.21E-08	5850	4.54E-10	9.92E-06
1794-OB8EP	A		FLEX I/O 24V DC electronically-fused output module	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	8770	Not allowed for 1oo1 configurations			1.60E-08	5850	1.00E-10	2.19E-06
1794-OB8EPXT	A		FLEX I/O-XT 24V DC electronically-fused output module	14,771,049	6.77E-08	3.38E-08	80%	1.35E-08	2.03E-08	8770				1.08E-07	5850	6.84E-10	1.49E-05
1794-OB16	A	Not Applicable	FLEX I/O 24V DC output module	54,322,632	1.84E-08	9.20E-09	80%	3.68E-09	5.52E-09	8770				2.95E-08	5850	1.85E-10	4.04E-06
1794-OB16P	A		FLEX I/O 24V DC protected output module	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	8770				1.60E-08	5850	1.00E-10	2.19E-06
1794-OB16PXT	A		FLEX I/O-XT 24V DC protected output module	26,709,401	3.74E-08	1.87E-08	80%	7.49E-09	1.12E-08	8770				5.99E-08	5850	3.77E-10	8.24E-06
1794-OW8	A		FLEX I/O isolated relay output module	29,088,895	3.44E-08	1.72E-08	80%	6.88E-09	1.03E-08	8770				5.50E-08	5850	3.46E-10	7.56E-06
1794-OW8XT	A		FLEX I/O-XT isolated relay output module	18,518,519	5.40E-08	2.70E-08	80%	1.08E-08	1.62E-08	8770				8.64E-08	5850	5.45E-10	1.19E-05
1794-IE8	B	Not Applicable	FLEX I/O analog input module	18,914,770	5.29E-08	2.64E-08	80%	1.06E-08	1.59E-08	8770	Not allowed for 1oo1 configurations			8.46E-08	5850	5.33E-10	1.17E-05
1794-IE8XT	B		FLEX I/O-XT analog input module	14,041,000	7.12E-08	3.56E-08	80%	1.42E-08	2.14E-08	8770				1.14E-07	5850	7.20E-10	1.57E-05
1794-IF4I	A	I	FLEX I/O isolated analog input module	9,885,959	1.01E-07	5.06E-08	80%	2.02E-08	3.03E-08	8770				1.62E-07	5850	1.03E-09	2.24E-05
1794-IF4IXT	A	I	FLEX I/O-XT isolated analog input module	7,297,140	1.37E-07	6.85E-08	80%	2.74E-08	4.11E-08	8770				2.19E-07	5850	1.40E-09	3.05E-05
1794-IF4ICFXT	A	I	FLEX I/O-XT isolated analog input module	7,297,140	1.37E-07	6.85E-08	80%	2.74E-08	4.11E-08	8770				2.19E-07	5850	1.40E-09	3.05E-05
1794-IR8	A	K	FLEX I/O RTD input module	5,016,231	1.99E-07	9.97E-08	80%	3.99E-08	5.98E-08	8770				3.19E-07	5850	2.06E-09	4.46E-05
1794-IR8XT	A	K	FLEX I/O-XT RTD input module	9,585,890	1.04E-07	5.22E-08	80%	2.09E-08	3.13E-08	8770				1.67E-07	5850	1.06E-09	2.31E-05
1794-IRT8	B	E.1	FLEX I/O RTD/Thermocouple input module	1,407,269	7.11E-07	3.55E-07	80%	1.42E-07	2.13E-07	8770				1.14E-06	5850	7.91E-09	1.67E-04
1794-IRT8XT	B	E.1	FLEX I/O-XT RTD/Thermocouple input module	8,204,792	1.22E-07	6.09E-08	80%	2.44E-08	3.66E-08	8770				1.95E-07	5850	1.24E-09	2.71E-05
1794-IT8	A	K	FLEX I/O Thermocouple input module	2,097,509	4.77E-07	2.38E-07	80%	9.54E-08	1.43E-07	8770				7.63E-07	5850	5.13E-09	1.10E-04
1794-IF2XOF2I	A	I	FLEX I/O isolated analog input/output module	8,464,844	1.18E-07	5.91E-08	80%	2.36E-08	3.54E-08	8770				1.89E-07	5850	1.20E-09	2.62E-05
1794-IF2XOF2IXT	A	I	FLEX I/O-XT isolated analog input/output module	6,317,918	1.58E-07	7.91E-08	80%	3.17E-08	4.75E-08	8770				2.53E-07	5850	1.62E-09	3.53E-05
1794-IE4XOE2XT	B	Not Applicable	FLEX I/O-XT analog input/output module	11,800,802	8.47E-08	4.24E-08	80%	1.69E-08	2.54E-08	8770				1.36E-07	5850	8.59E-10	1.87E-05
1794-OE4	B		FLEX I/O analog output module	18,433,610	5.42E-08	2.71E-08	80%	1.08E-08	1.63E-08	8770	Not allowed for 1oo1 configurations			8.68E-08	5850	5.47E-10	1.20E-05
1794-OE4XT	B		FLEX I/O-XT analog output module	11,381,744	8.79E-08	4.39E-08	80%	1.76E-08	2.64E-08	8770				1.41E-07	5850	8.91E-10	1.94E-05
1794-OF4I	A	I	FLEX I/O analog output module	23,884,409	4.19E-08	2.09E-08	80%	8.37E-09	1.26E-08	8770				6.70E-08	5850	4.21E-10	9.22E-06
1794-OF4IXT	A	I	FLEX I/O-XT analog output module	5,493,902	1.82E-07	9.10E-08	80%	3.64E-08	5.46E-08	8770				2.91E-07	5850	1.87E-09	4.07E-05

Table 12 - 5-Year PFD Calculations

Cat No.[1]	Series	Firmware Version[6]	Description	Mean Time between Failure (MTBF)[7]	Common Terms[8]						1oo1 Configuration			1oo2 Configuration			
					λ[9]	λ_s , λ_d	Safe Failure Fraction (SFF)	λ_{du}	λ_{dd}	T_{CE1oo1}	Spurious Trip Rate STR	PFH[10]	PFD	Spurious Trip Rate STR	T_{GE}	PFH[10]	PFD
1794-TB3	A	Not Applicable	FLEX I/O terminal base unit	250,000,000	4.00E-09	2.00E-09	80%	8.00E-10	1.20E-09	8770	Not allowed for 1oo1 configurations			6.40E-09	5850	4.00E-11	8.77E-07
1794-TB3G	A		FLEX I/O cage-clamp generic terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	8770				1.60E-08	5850	1.00E-10	2.19E-06
1794-TB3GS	A		FLEX I/O spring-clamp generic terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	8770				1.60E-08	5850	1.00E-10	2.19E-06
1794-TB3S	A		FLEX I/O terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	8770				1.60E-08	5850	1.00E-10	2.19E-06
1794-TB3T	A		FLEX I/O temperature terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	8770				1.60E-08	5850	1.00E-10	2.19E-06
1794-TB3TS	A		FLEX I/O spring-clamp temperature terminal base unit	52,312,000	1.91E-08	9.56E-09	80%	3.82E-09	5.73E-09	8770				3.06E-08	5850	1.92E-10	4.20E-06
1794-TBN	A		FLEX I/O NEMA terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	8770				1.60E-08	5850	1.00E-10	2.19E-06
1794-TBNF	A		FLEX I/O NEMA fused terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	8770				1.60E-08	5850	1.00E-10	2.19E-06
1492-TIFM40F-F24A-2[5]	A	Not Applicable	DC Input Termination Board	7,779,000	Non-interference only						7.04E-08	Not Applicable		1.03E-07	Not Applicable		
1492-TAIFM16-F-3[5]	A		Analog Input Termination Board	11,362,000							7.90E-08			7.04E-08			
1492-TIFM40F-24-2[5]	A		DC Output Termination Board	10,127,000							0.00E+00			0.00E+00			

(1) Some catalog numbers have a K suffix. This indicates a version of the product that has conformal coating. These K versions have the same SIL 2 certification as the non-K versions. For more information on which products have conformal coating go to http://ab.com.rockwellautomation.com/

(2) Average of 1756-A4, -A7, -A10, -A13 and -A17 chassis.

(3) Suitable for use only in applications requiring compliance to IEC 61508 1999 Edition 1

(4) Calculated MTBF and PFD by FMEA to 61508-2010.

(5) SIL 2-rated for non-interference in the chassis. Data not required within a safety function.

(6) For the latest official approved firmware versions, consult the Revision Release List, Certificate Number 968/EZ/35.xx/xx available at http://www.rockwellautomation.com/rockwellautomation/certification/safety.page.

(7) MTBF measured in hours unless calculated (as noted). Field return values – January 2012.

(8) Calculations performed on a per module basis.

(9) λ = Failure Rate = 1/MTBF.

(10) Demand rate must be less than 10 per year

Using Component Values To Calculate System PFD

The system PFD value is calculated by totaling the PFD value of each component in the system. To calculate a system PFD value, use this equation:

- modA PFD + modB PFD + modC PFD = system PFD

where mod*X* PFD is the PFD value for one component or module in the system. When calculating your system PFD, verify that all the components used in the system are totaled.

Example: 1-year PFD Calculation for a ControlLogix System (1oo1 Configuration)

This example shows an example of a PFD calculation for a traditional ControlLogix system in a fail-safe configuration. This example system uses one chassis for the controller and a second chassis for the I/O.

Table 13 - Example of PFD Calculations for a Fail-safe System (1oo1 Configuration)

Cat. No.	Description	Calculated
1756-IB16D	ControlLogix V DC diagnostic input module	1.46E-06 (1oo2)
1756-EN2TR Series C	ControlLogix EtherNet/IP communication module - I/O chassis	3.00E-04 (1oo1)
1756-L72	ControlLogix controller, 4 MB	4.50E-04 (1oo1)
1756-EN2TR Series C	ControlLogix EtherNet/IP communication module - controller chassis	3.00E-04 (1oo1)
1756-OB16D	ControlLogix V DC diagnostic output module	4.97E-06 (1oo2)
Total safety loop PFD:		**1.056E-03**
Percent of SIL 2 budget:		**10.56%**

Example: 1-year PFD Calculation for a ControlLogix System (1oo2 Configuration)

See Figure 6 on page 20 for a system diagram of the example calculation shown below.

Cat. No.	Description	Calculated
1756-IB16D	ControlLogix V DC diagnostic input module	1.46E-06 (1oo2)
1756-EN2TR Series C	ControlLogix EtherNet/IP communication module - I/O chassis	6.11E-06 (1oo2)
1756-L72	ControlLogix controller, 4 MB	4.50E-04 (1oo1)
1756-EN2TR Series C	ControlLogix EtherNet/IP communication module - controller chassis	6.11E-06 (1oo2)
1756-OB16D	ControlLogix V DC diagnostic output module	4.97E-06 (1oo2)
Total safety loop PFD:		**4.69E-04**
Percent of SIL 2 budget:		**4.69%**

Using ControlLogix and FLEX I/O Modules in SIL 1 Applications

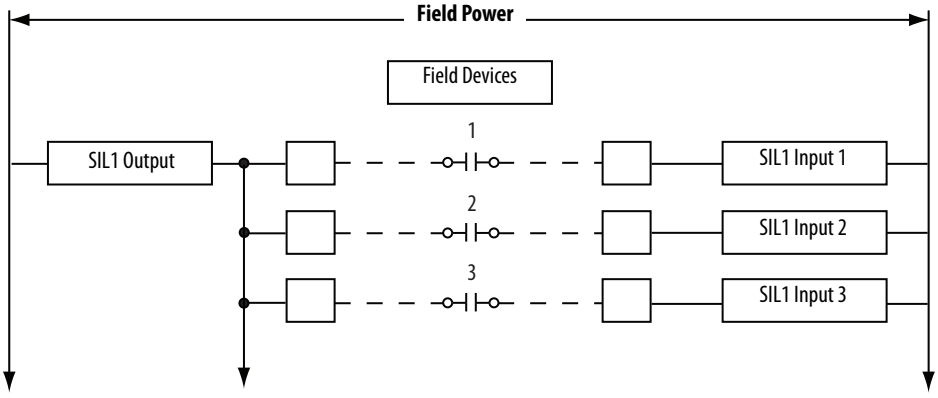
Approved 1756 I/O modules may be used in a 1oo1 architecture; however, you must follow the guidelines listed in Table 14 on page 138.

If you plan to use 1794 FLEX I/O modules in a SIL 1 1oo1 configuration, in addition to following the guidelines in Table 14, you must also implement appropriate field diagnostics as defined below:

- Field diagnostics must execute once every eight hours.
- An output or other sensing device must be used to provide field power control to the digital inputs. See the SIL 2 output guidelines in Chapter 5, ControlLogix I/O Modules.
- You must consider the time it takes a diagnostic to execute when determining the safety reaction time because safety demands will not be detectable if they occur during a diagnostic.

  The diagnostic you implement must monitor the ability of all SIL 1 inputs to detect a change of state. One method would be to turn off the output and monitor that all SIL 1 inputs detect the loss of signal within a short period of time. Then, when the output turns back on, make sure that all SIL 1 inputs properly detect the change. You need to consider and mitigate any impact to your system while the diagnostic is executing.

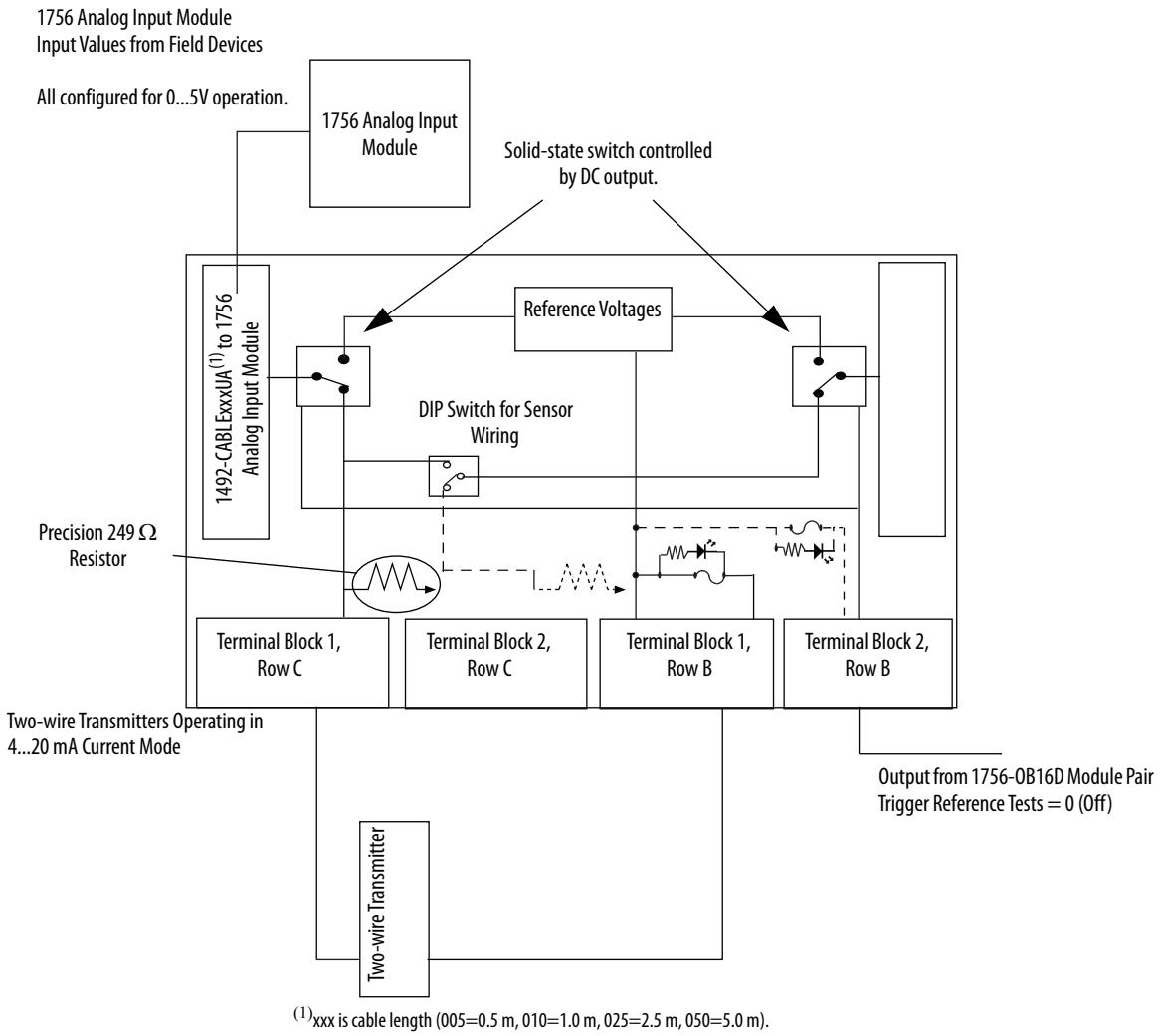
Figure 64 - SIL 1 Digital Input Wiring Example for 1794 I/O Modules



TIP Field diagnostics as described for 1794 I/O modules can also be used to meet the requirements for periodic proof testing with either 1794 or 1756 I/O modules.

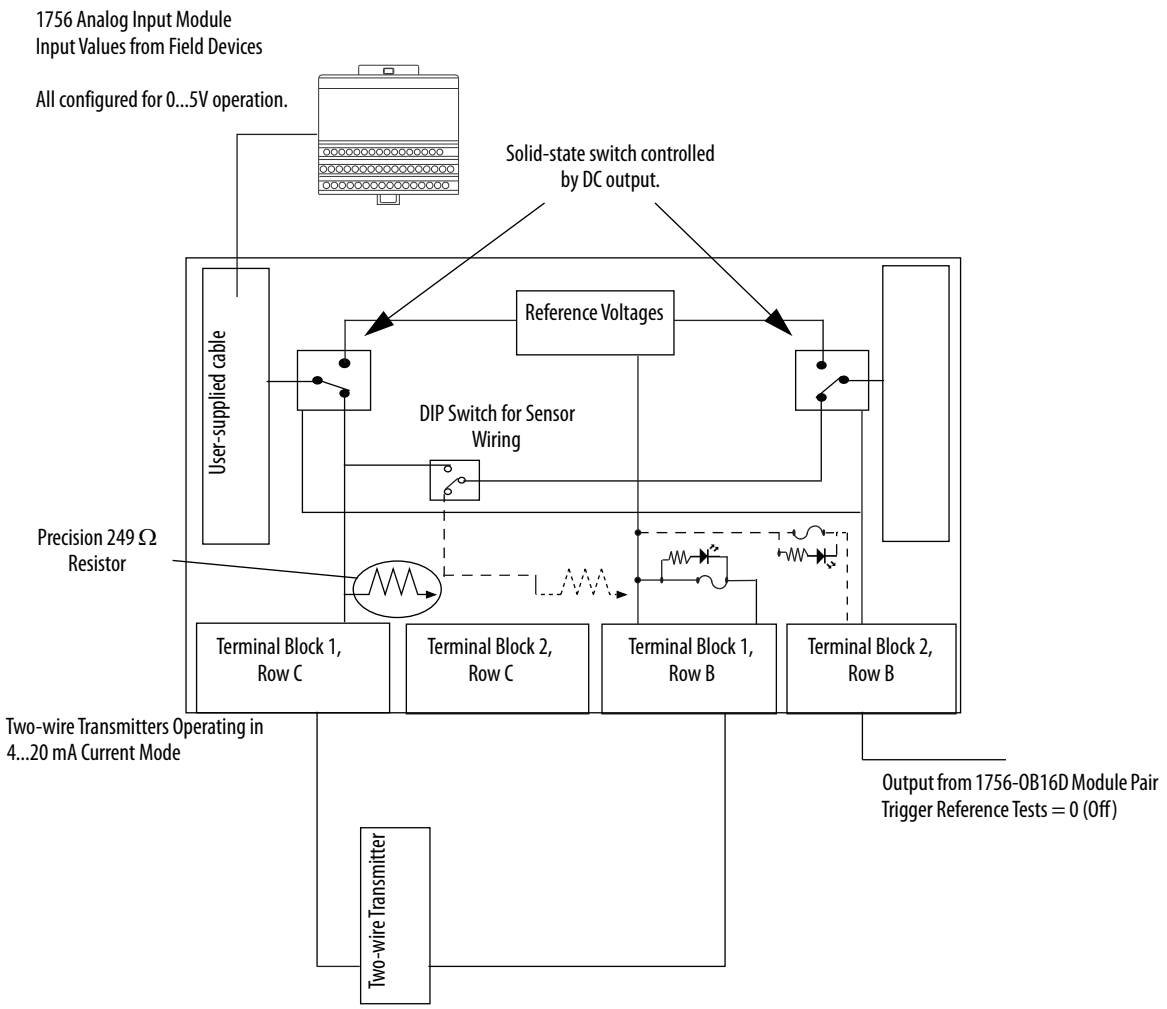
Termination boards 1492-TIFM16-F-3 can be used to provide a voltage reference for periodic testing as shown below.

Figure 65 - SIL 1 1756 Analog Input Wiring Example (Simplex)


1756 Analog Input Module
Input Values from Field Devices
All configured for 0...5V operation.
1756 Analog Input Module
Solid-state switch controlled by DC output.
1492-CABLExxxxUA(1) to 1756 Analog Input Module
Reference Voltages
DIP Switch for Sensor Wiring
Precision 249 Ω Resistor
Terminal Block 1, Row C
Terminal Block 2, Row C
Terminal Block 1, Row B
Terminal Block 2, Row B
Two-wire Transmitters Operating in 4...20 mA Current Mode
Output from 1756-OB16D Module Pair
Trigger Reference Tests = 0 (Off)
Two-wire Transmitter

(1)xxx is cable length (005=0.5 m, 010=1.0 m, 025=2.5 m, 050=5.0 m).

Figure 66 - SIL 1 1794 Analog Input Wiring Example (Simplex)


1756 Analog Input Module
Input Values from Field Devices
All configured for 0...5V operation.
Solid-state switch controlled by DC output.
Reference Voltages
User-supplied cable
DIP Switch for Sensor Wiring
Precision 249 Ω Resistor
Terminal Block 1, Row C
Terminal Block 2, Row C
Terminal Block 1, Row B
Terminal Block 2, Row B
Two-wire Transmitters Operating in 4...20 mA Current Mode
Output from 1756-OB16D Module Pair
Trigger Reference Tests = 0 (Off)
Two-wire Transmitter

To make your own cable, follow the termination board pinout shown below.

P1 Pins	Description
3	Input 0
2	Input 1
1	Input 2
14	Input 3
15	Input 4
16	Input 5
17	Input 6
18	Input 7
12	Input 8
13	Input 9
25	Input 10
24	Input 11
23	Input 12
22	Input 13

P1 Pins	Description
20	Input 14
21	Input 15
4	RTN
6	RTN
8	RTN
10	RTN

When using controllers and network communication modules, follow the guidelines listed in this safety manual.

IMPORTANT When using 1756 or 1794 outputs in SIL 1 configurations, you must implement a secondary means to shut off the outputs.

Table 14 lists additional considerations that must be made with various ControlLogix modules in a SIL1 application.

Table 14 - Considerations for SIL1 Applications by Module

Module	Additional considerations
Controllers	None. Use the controller exactly as described previously in this manual.
ControlNet modules	None. Use the modules exactly as described previously in this manual.
Ethernet modules	None. Use the modules exactly as described previously in this manual.
Digital output modules(1)	Diagnostic output modules are recommended in a SIL1 application. Implement a secondary shutdown path if the SIL1 application requires a fail-safe OFF in the event of a shorted output.
Digital input modules(2)	Only one module is required in a SIL1 application. Periodic tests of the inputs should be performed as described previously in this manual.
Analog output modules(1)	Analog output modules should be wired as described previously in this manual.
Analog input modules(2)	Only 1 module is required in a SIL1 application. Periodic tests of the inputs should be performed as described previously in this manual.

(1) The user should be alerted to any detected output failures.

(2) The test interval of module inputs must be specified according to application-dependent standards. For example, according to EN50156, the time for fault detection and tripping must be less than or equal to the fault tolerance time.

Checklists

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Checklist for SIL Outputs	142
Checklist for the Creation of an Application Program	143

Checklist for the ControlLogix System

The following checklist is required for planning, programming and start up of a SIL 2-certified ControlLogix system. It may be used as a planning guide as well as during proof testing. If used as a planning guide, the checklist can be saved as a record of the plan.

Check List for ControlLogix System(1)

Company:

Site:

Loop definition:

No.		Fulfilled		Comment
		Yes	No	
1	Are you only using the SIL 2-certified ControlLogix modules with the corresponding firmware release listed in Revision Release List (available from the Product Certification link at http://www.ab.com) for your safety application?	☐	☐	
2	Have you calculated the system's response time?	☐	☐	
3	Does the system's response time include both the user-defined, SIL-task program watchdog (software watchdog) time and the SIL-task duration time?	☐	☐	
4	Is the system response time in proper relation to the process tolerance time?	☐	☐	
5	Have PFD values been calculated according to the system's configuration?	☐	☐	
6	Have you performed all appropriate proof tests?	☐	☐	
7	Have you defined your process parameters that are monitored by fault routines?	☐	☐	
8	Have you determined how your system will handle faults?	☐	☐	
9	Have you taken into consideration the checklists for using SIL inputs and outputs listed on pages 140 and 142.	☐	☐	

(1) For more information on the specific tasks in this checklist, see the previous sections in the chapter or Chapter 1, SIL Policy on page 13.

Checklist for SIL Inputs

The following checklist is required for planning, programming and start up of SIL inputs. It may be used as a planning guide as well as during proof testing. If used as a planning guide, the checklist can be saved as a record of the plan.

For programming or start-up, an individual checklist can be filled in for every single SIL input channel in a system. This is the only way to make sure that the requirements were fully and clearly implemented. This checklist can also be used as documentation on the connection of external wiring to the application program.

Input Module Check List for ControlLogix System

Company:				
Site:				
Loop definition:				
SIL input channels in the:				
No.	**All Input Module Requirements (apply to both digital and analog input modules)**	**Yes**	**No**	**Comment**
1	Is Exact Match selected as the electronic keying option whenever possible?	☐	☐	
2	Is the RPI value set to an appropriate value for your application?	☐	☐	
3	Are all modules owned by the same controller?	☐	☐	
4	Have you performed proof tests on the system and modules?	☐	☐	
5	Have you set up the fault routines?	☐	☐	
6	Are control, diagnostics and alarming functions performed in sequence in application logic?	☐	☐	
7	For applications using FLEX I/O modules, is the application logic monitoring one ControlNet status bit for the associated module, and is appropriate action invoked via the application logic by these bits?	☐	☐	
No.	**Additional Digital Input Module-Only Requirements**	**Yes**	**No**	**Comment**
1	When two digital input modules are wired in the same application, do the following conditions exist: • Both modules are owned by the same controller. • Sensors are wired to separate input points. • The operational state is ON. • The non-operational state is. OFF. • Configuration parameters (for example, RPI, filter values) are identical. • For FLEX input modules, both module are on different ControlNet nodes	☐	☐	
2	For the standard input modules, is the Communication Format set to one of the Input Data choices?	☐	☐	
3	For the diagnostic input modules, is the Communication Format set to Full Diagnostics-Input Data?	☐	☐	
4	For the diagnostic input modules, are all diagnostics enabled on the module?	☐	☐	
5	For the diagnostic input modules, are enabled diagnostic bits monitored by fault routines?	☐	☐	
6	For the diagnostic input modules, is the connection to remote modules a direct connection?	☐	☐	

Input Module Check List for ControlLogix System

No.	Additional Analog Input Module-Only Requirements	Yes	No	Comment
1	Is the Communication Format set to Float Data?	☐	☐	
2	Have you calibrated the modules as often as required by your application?	☐	☐	
3	Are you using ladder logic to compare the analog input data on two channels to make sure there is concurrence within an acceptable range and that redundant data is used properly?	☐	☐	
4	Have you written application logic to examine bits for any condition that may cause a fault and appropriate fault routines to handle the fault condition?	☐	☐	
5	When two FLEX I/O analog input modules are wired in the same application, are both module on different ControlNet nodes?	☐	☐	
6	When wiring an analog input module in Voltage mode, are transmitter grounds tied together?	☐	☐	
7	When wiring an analog input module in Current mode, are loop devices placed properly?	☐	☐	
8	When wiring thermocouple modules in parallel, have you wired to the same channel on each module as shown in Figure 33 on page 64?	☐	☐	
9	When wiring two RTD modules, are two sensors used, as shown in Figure 34 on page 65?	☐	☐	

Checklist for SIL Outputs

The following checklist is required for planning, programming and start up of SIL outputs. It may be used as a planning guide as well as during proof testing. If used as a planning guide, the checklist can be saved as a record of the plan.

For programming or start-up, an individual requirement checklist must be filled in for every single SIL output channel in a system. This is the only way to make sure that the requirements are fully and clearly implemented. This checklist can also be used as documentation on the connection of external wiring to the application program.

Output Check List for ControlLogix System

Company:				
Site:				
Loop definition:				
SIL output channels in the:				
No.	**All Output Module Requirements (apply to both digital and analog output modules)**	**Yes**	**No**	**Comment:**
1	Have you performed proof tests on the modules?	☐	☐	
2	Is Exact Match selected as the electronic keying option whenever possible?	☐	☐	
3	Is the RPI value set to an appropriate value for your application?	☐	☐	
4	Have you set up fault routines, including comparing output data with a corresponding input point?	☐	☐	
5	If required, have you used external relays in your application to disconnect module power if a short or other fault is detected on the module or isolated output in series?	☐	☐	
6	Is the control of the external relay implemented in ladder logic?	☐	☐	
7	Have you examined the Output Data Echo signal in application logic?	☐	☐	
8	Are all outputs configured to de-energize in the event of a fault or the controller entering Program mode?	☐	☐	
9	Do two modules of the same type, used in the same application, use identical configurations?	☐	☐	
10	Does one controller own both modules if two of the same type are used in an application?	☐	☐	
11	Are control, diagnostics and alarming functions performed in sequence in application logic?	☐	☐	
No.	**Digital Output Module-Only Requirements**	**Yes**	**No**	**Comment**
1	For the standard output modules, is the Communication Format set to Output Data?	☐	☐	
2	For standard output modules, have you wired the outputs to a corresponding input to validate that the output is following its commanded state?	☐	☐	
3	For the diagnostic output modules, are all diagnostics enabled on the module?	☐	☐	
4	For the diagnostic output modules, are enabled diagnostic bits monitored by fault routines?	☐	☐	
5	For the diagnostic output modules, is the Communication Format set to Full Diagnostics-Output Data?	☐	☐	
6	For diagnostic output modules, have you periodically performed a Pulse Test to make sure that the output is capable of change state?	☐	☐	
7	For diagnostic output modules, is the connection to remote modules a direct connection?	☐	☐	

Output Check List for ControlLogix System				
No.	**Analog Output Module Requirements - Analog Only**	**Yes**	**No**	**Comment**
1	Is the Communication Format set to Float Data?	☐	☐	
2	Have you calibrated the modules as often as required by your application?	☐	☐	
3	When wiring an analog output module in Current mode, are loop devices placed properly?	☐	☐	
4	Have you written application logic to examine bits for any condition that may cause a fault and appropriate fault routines to handle the fault condition?	☐	☐	

Checklist for the Creation of an Application Program

The following checklist is recommended to maintain safety technical aspects when programming, before and after loading the new or modified program.

Checklist for Creation of an Application Program Safety Manual ControlLogix System
Company:
Site:
Project definition:
File definition / Archive number:

Notes / Checks	Yes	No	Comment
Before a Modification			
Are the configuration of the ControlLogix system and the application program created on the basis of safety aspects?	☐	☐	
Are programming guidelines used for the creation of the application program?	☐	☐	
After a Modification - Before Loading			
Has a review of the application program with regard to the binding system specification been carried out by a person not involved in the program creation?	☐	☐	
Has the result of the review been documented and released (date/signature)?	☐	☐	
Was a backup of the complete program created before loading a program in the ControlLogix system?	☐	☐	
After a Modification - After Loading			
Was a sufficient number of tests carried out for the safety relevant logical linking (including I/O) and for all mathematical calculations?	☐	☐	
Was all force information reset before safety operation?	☐	☐	
Has it been verified that the system is operating properly?	☐	☐	
Have the appropriate security routines and functions been installed?	☐	☐	
Is the controller keyswitch in Run mode and the key removed?	☐	☐	

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